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Agricultural and Horticultural Research Station.

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

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INTRODUCTION.

In comparison with most recent years the year 1925 produced no considerable changes in staff at the Institute. As a result it has been possible to concentrate on the investigations in hand and to maintain continuity under more favourable conditions than usual. Substantial progress has been made in most of the main lines of research. In addition to what is included in the present Report there is much matter now either in preparation for publication or being held back for confirmation by a further season's results.

While progress at Long Ashton has been steady and generally satisfactory, the natural development of the work during the year has brought to a head serious problems for the immediate future which are a source of anxiety and cannot be shelved without detriment to the efficiency of the Station. For example, the expansion of the Staff on the scientific side since the war has resulted in overcrowding in the laboratory building to such an extent that certain lines of work urgently requiring attention and demanding adequate laboratory space cannot be proceeded with under present conditions, while accommodation for research students and voluntary workers is not available. The growth of the scientific staff has also been responsible for so rapid an increase in the number of field experiments in progress at the Station that the whole of the part of Fenswood Farm which had been taken over for this purpose is now appropriated to specific objects.

The provision of laboratory extension and additional land, the two most pressing needs, is referred to further in the sections on Land and Buildings. Other needs are of less immediate urgency, but are definitely in sight. A financial problem of some magnitude thus faces the Station. Any material increase in the maintenance grant received from the Ministry of Agriculture is improbable in the near future and cannot be expected till the financial position of the country has improved. The Station must therefore look to new support from other sources to meet the normal increase in expenditure required to carry through the programme of work already in hand, leaving aside altogether any question of further expansion. Indeed, for the next few years at least it would appear that the policy of the Station should be to stabilise the present position and justify it.

There has been rapid development in the two other associated sections of the work of this Department of Bristol University, viz.,

the agricultural advisory work under the charge of Dr. Hanley, now being conducted from the new centre at Berkeley Square, Bristol, and the work on fruit and vegetable preservation carried on through the Campden Research Station. Although some reference to the activities of these two centres is necessary on account of their intimate connection with the Long Ashton Institute, it is proposed to confine the present Report primarily to the work of the latter Station.

The personnel of the research and advisory staff located at Long Ashton has remained unchanged throughout the year.

Changes in the assistant staff have been caused by the resignation of Mr. E. H. M. Barker, pomological assistant, and the transfer of Mr. A. W. Ling, assistant chemist, to the Berkeley Square Advisory Centre on his appointment as Advisory Agricultural Chemist. The latter has been succeeded by Mr. H. R. Osmond, B.Sc., A.I.C., from the Chemical Department of Bristol University. Mr. Barker's post has not yet been filled, the work in the meantime having been carried on by Mr. P. T. Pickford, a student-assistant, and Mr. E. Umpleby, who, as assistant recorder, is in charge of the nursery work of the Station.

Mr. T. W. Swarbrick, B.Sc., a research scholar of the Ministry of Agriculture from Leeds University, has been stationed at Long Ashton to carry out an investigation on the healing of wounds of woody tissues, which is closely concerned with many points of importance in pomological practice.

A grant has been obtained from the Development Fund for a special investigation on certain physical and chemical problems of tar-distillate spray fluids. The work has been placed in the hands of Mr. L. Smith, B.Sc., a research student of Bristol University working under Professor McBain's direction in the Department of Chemistry.

The rearrangement involved by the development of the Advisory Scheme under Dr. Hanley and the opening of the new laboratories and offices for the agricultural side of the work at Berkeley Square, Bristol, are further referred to in the section on Advisory Work.

At the Campden Research Station, where the Department is at present conducting most of its work on the problems of fruit and vegetable preservation, Miss M. J. M. Watson, who has for some years been in charge of the Home Kitchen section, has resigned her post on receiving an appointment as Inspectress in Domestic Science under the Board of Education for Scotland. A successor will be appointed early in 1926. Dr. Paton, who has for some time been engaged in research in the Brewing Department of Birmingham

University, has been selected to fill the new post of Assistant Chemist.

Land and Plantations.—The problem of providing land for the extension of the experimental work on fruit culture in the field has already been mentioned. When Fenswood Farm was purchased in 1920 it was hoped that the land thus secured would serve as a reserve upon which to draw for extension for many years to come. It was recognised at the time that certain portions were unsuited for fruit culture and that parts of the remainder, while capable of growing fruit, were not sufficiently good for any type of field trial. The knowledge which has been gained during the course of the Fruit Soils Survey and of further experience and a closer examination of the soil conditions over all parts of the farm has shown that a substantial part of the land which had been originally regarded as possible for experimental work on fruit culture is below the necessary standard of evenness. Expansion of field experiments has proceeded so rapidly that by the spring of 1925 the whole of the suitable land, except some thirty acres adjacent to the farmhouse and buildings, had been absorbed. Since this is required in the immediate future for the programme of rootstock trials and other investigations already in hand, it has been found necessary to terminate Mr. Prideaux's tenancy of the farm. In consequence the Station has now taken in charge the whole of the farm and will itself conduct the farming operations pending a decision as to the course to be taken with regard to the portions unsuitable for experimental work. With the termination of the association of Mr. Prideaux with the Institute, acknowledgment should be made of the help he has willingly rendered in many ways and the readiness with which he has invariably accepted modifications in his holding which have been called for by the extension of the work of the Institute.

While the immediate calls for land have thus been met, the fact cannot be ignored that various investigations on which work has already proceeded some distance are maturing and will demand field tests at no distant date. These needs can only be met either by scrapping existing plots which have already yielded sufficient results or by obtaining suitable land outside the farm. The former alternative in course of time might serve—to a very limited extent it is being adopted already—but for the near future it is open to the serious objections that in many cases conclusions would be based on results not extending over the normal life of a plantation, and that the trees would be sacrificed as they were approaching their most profitable stage. The second alternative is now being explored, but the prospects of obtaining any considerable area of suitable land near the Institute are not bright.

New plots established during the year on land which had been previously in preparation for fruit include a trial plantation of bush apples on selected free stocks, various strawberry plots concerned with aspects of the extensive programme of strawberry investigations referred to later, a raspberry variety trial plot, extensions of seedling trial plantations, a black currant plot for further work on reversion disease, and a plantation of bush apples for investigations on the nature of the reciprocal influence of scion and rootstock.

The willow plantations have been extended to accommodate new additions to the willow variety collection.

Buildings. From the start of the Institute the lack of attached cottages for housing skilled labour has been a severe handicap owing to the necessity of importing trained men into Long Ashton and the scarcity of available cottage accommodation in the neighbourhood. The decision of the Committee to erect a house for the Plantations Officer and four cottages for other members of the plantations staff should, therefore, ensure a degree of efficiency in the plantation work which it has not been hitherto possible to reach. These houses are now nearing completion and should be in readiness for occupation early in 1926.

The taking over of Fenswood Farm has placed at the disposal of the Institute a series of farm buildings which are proving of great service. More storage and other accommodation is constantly being required as the work in the fruit plantations and cider house expands, and additional expenditure on that account is being avoided by utilising some of these buildings now available.

It has already been mentioned that a serious need for more laboratory accommodation has arisen. This need may be intensified if certain changes relating to other sections of the work of the Department now under contemplation are approved. Plans for an addition to the existing building have been prepared and estimates obtained. The approximate cost is likely to be £5,000. This sum must be raised before the scheme can be proceeded with, since the Station has no funds of its own available for the purpose. While a grant-in-aid from the Development Fund may be secured, this will not exceed one-half of the total cost.

General. The Fruit Soils Survey as originally planned is now in its fourth and final year. The major part of the work involved has been completed and the report upon it is now in course of preparation. The results of the Survey fully justify both the great amount of time that has been given to it and the extension of the investigation to other soil types. It is, there-

fore, gratifying to be able to record that a further grant from the Ministry of Agriculture has been promised to enable the survey to be extended to cover both the important fruit area in West Cambridgeshire centred around Histon, Cottenham and Willingham, and the Lias Clay formation, which embraces some of the principal fruit districts in the Bristol Province. As before, members of the staff of the Horticultural Department of Cambridge University will be responsible for the Eastern Counties section of the Survey, while the Long Ashton staff will undertake the work in the West. The latter will on this occasion also include the agricultural aspect, and Dr. Hanley and other members of the Berkeley Square staff will, therefore, co-operate with the Long Ashton workers.

Educational exhibits were staged during the year at the following Shows :—

British Empire Exhibition, Wembley Park.
Devon County Show, Plymouth.
Somerset Agricultural Show, Weston-super-Mare.
Wiltshire Agricultural Show, Warminster.
Bath and West and Southern Counties Show, Maidstone.
Royal Horticultural Society's Show, Chelsea.
Three Counties Agricultural Show, Hereford.
Cheltenham Floral Fête, Cheltenham.
Monmouthshire Agricultural Show, Monmouth.
Usk Agricultural Show, Usk.
Imperial Fruit Show, London.

At the Imperial Fruit Show, which on this occasion was held in London at the Holland Park Skating Rink, the Institute in addition to its exhibit relating to the Long Ashton work organised and conducted on behalf of the National Association of Cider Makers a series of demonstrations of cider making, these being given daily throughout the Show. The staff at Campden also contributed an exhibit dealing with fruit and vegetable preservation and gave demonstrations of methods of canning and bottling. It also contributed a section to the exhibit of the Ministry of Agriculture and Fisheries in the Government Pavilion at the British Empire Exhibition at Wembley, as in 1924.

In view of the economic importance and educational value of many of the results which are coming to hand in different investigations at Long Ashton and cannot be seen at the time of year when the usual Field Days are held, it was decided to throw the Station open in a similar way at more frequent intervals during 1925, thus giving visitors an opportunity of seeing experiments and results which would otherwise be missed by them. Accordingly, in addition to the Annual Tasting Day held on May 7th, and the Plantations Field Day, held on September 15th, both of which were attended even more numerously than usual, a series of Open Days was arranged, the programme of demonstrations being limited to special subjects

seasonable for the time of year. The attendances on these occasions ranged from about thirty to over a hundred, numbers which must be considered as very satisfactory since, from the nature of the case, many visitors from a distance could not be expected on any single occasion. The degree of interest shown was encouraging and would certainly justify, from the educational point of view alone, a corresponding arrangement as a regular feature in future years. On the other hand, it must be borne in mind that these occasions involve considerable preparation and time and are a distraction to the research worker at his busiest period. Hence some departure from the original method will probably be found necessary. The thanks of the Station are due to the Press for giving notice of the dates of these Open Days and accounts of the programme of the individual occasions. These were as follows :—

March 25th,	1925	I.	Nutrition of Fruit Trees.
		II.	Die-Back Diseases in Fruit Trees.
		III.	Tar Distillate Washes (Carbo Fluids). Their use as Egg-killing Washes.
		IV.	Scab Diseases of Apples and Pears.
		V.	Winter Pruning of Apple Trees.
April 29th,	,,	I.	Breeding New Varieties of Fruits.
		II.	Self Sterility of Fruit Trees.
		III.	American Gooseberry Mildew.
		IV.	Control of Plum Aphis by Winter Washes.
		V.	The Control of Big Bud Mite on Black Currants with Lime Sulphur.
June 17th	,,	I.	Reversion Disease of Black Currants.
		II.	"Big Bud" ,, ,, ,, ,,
July 22nd,	,,	I.	The Bottling of Fruit, with particular reference to the Soft Fruits.
		II.	Fruit Canning, using a Hand Can Sealer.
		III.	Raspberry Varieties.
November 25th,	,,	I.	Cider Making.

The scheme for the provision of local instruction in cider-making referred to in last year's Report has proceeded a further stage. The County Councils of Dorset, Monmouth and Worcester have decided to co-operate in a scheme under which a full-time Instructor will be located at the Institute and available for service in those counties. The Ministry of Agriculture is also contributing a grant-in-aid. Pending the completion of the period of special training of the Instructor, Mr. Grove has, as in 1924, given local demonstrations and paid a number of advisory visits. In Gloucestershire the County Council is providing instruction and local advice by an Instructor trained at Long Ashton prior to the war. The Somerset County Council has approved the appointment of a full-time Instructor and has nominated the selected candidate for a special course of training at the Institute. In Devon the local authority contemplates making provision for instruction by one of the members of its staff. Thus there will now be available over by far

the greater part of the cider-producing area in the West of England facilities for obtaining local advice and instruction in this subject.

During the course of the negotiations for the provision of local instruction in cider-making it became evident that there was a real need for a centre for technical training of a more advanced character, suited for those intending to prepare for commercial cider-making or to qualify as instructors in the subject. Hitherto the Institute has given training in isolated cases, but has done little in the direction of organised courses. A scheme for a special course to be given at Long Ashton is now under consideration, particulars of which will be circulated to prospective students on application.

The development of the scheme for local instruction in cider-making necessarily involves a renewal of effort to improve the condition of farm orcharding. In this connection the various trial and demonstration orchards established in contributing counties with trees supplied by the Institute have mostly reached a stage at which they can serve as valuable object lessons. The establishment of similar orchards at suitable new centres is being proceeded with and a number of trees were sent out for the purpose from the Institute nursery during the past planting season.

In an altogether different direction the Institute has been able during the year to render service to the cider industry. The introduction by the Ministry of Health of new regulations relating to the use of preservatives in foods and drinks has raised a number of questions of serious importance to the industry, more particularly in relation to the practice of sulphuring. This custom has always been regarded as legitimate in the fermentation industries and has been sanctioned by time-honoured usage. In its negotiations with the Ministry the National Association of Cider Makers has had placed at its disposal the services of the technical staff of the Institute, both at the official discussions and by means of the considerable amount of laboratory investigations which have been involved in connection therewith. As a result the proposed regulations in their present form, due to come into operation in 1927, while adequately safeguarding public health, will effect this object in a manner much more satisfactory to the industry than the original proposals. The Association has expressed its warm appreciation of the help given by the Institute in the matter. Since the subject was first raised the Institute has carried out many experiments relating to the practice of sulphuring and the limits of its utility. The results will be published for the guidance of makers as soon as they are complete and it is expected that it will be possible for them to have this information in their hands before the regulations come into force: but it has been considered advisable to defer

publication in the Annual Report until a record of the complete investigation can be given. Several useful facts have already been obtained and it is suggested that makers requiring early information on the practice of sulphuring in relation to the new regulations should communicate with the Director or Mr. Grove.

During the year there has been a considerable development of co-operative work with other centres, of which mention may be made here of the following.

The first joint meeting of the full staffs of the East Malling Fruit Research Station and the Long Ashton Station was held at the latter place in October. The relations and joint working arrangements of the two Stations were discussed and plans for co-operation and co-ordination of work approved. The respective programmes of research were considered item by item and, where desirable, collaboration arranged. Subsequently a series of group meetings between the various members of the staffs concerned with joint work took place, at which the details of the latter were settled. It is intended to hold these meetings annually in future. They should be the means of ensuring the closest touch between the two Stations in their work, the corresponding avoidance of unnecessary overlapping, the utilisation of opportunities for desirable duplication of experiments, and the promotion of cordial working relations.

In a somewhat similar way working arrangements have been established between the advisory and research staffs of the Department and the agricultural and horticultural staffs of the five counties comprising the Bristol Province. Since the war regular joint meetings have been held three or four times annually and a system of collaboration in the advisory and experimental work within the Province organised. In 1924 an extension of the arrangement was made to include the three counties of the Harper-Adams Province, Shropshire, Staffordshire and Warwickshire, and its advisory and collegiate centre at Harper-Adams College, the meetings in this case being annual. The first took place at Long Ashton in September, 1924, and the second at Harper-Adams College in July, 1925.

The conjoint work between the Institute staff and that of the associated counties has extended beyond that of a purely advisory or field trial character. For example, at the Worcestershire Horticultural Station at Perdiswell manurial trials on strawberries on similar lines to those in progress at Long Ashton and the Botley Experimental Fruit Station in Hampshire have been started. At the same centre some of the more promising black currant seedlings raised at Long Ashton and the selected forms of seedling apple stocks are also under trial. Trees on the latter are also being raised in the nursery of the Institute for trials to be carried out at the Somerset Farm Institute at Cannington.

Under the Fruit Variety Trials scheme, for which Wisley serves as the main Station, it has been arranged that a Sub-Station should be established at the Institute. The first batch of material for trial has already been received and is being planted out during the current planting season.

The Institute continues its close association with the experimental work on strawberries at the Botley Experimental Fruit Station. Interesting comparative results are being obtained from the duplicate trials at the two Stations, to which reference was made in the last Annual Report.

The serious situation existing throughout the strawberry growing districts on account of the poor condition of a large percentage of the plants has caused the plant pathologists in the districts concerned to give considerable attention to this trouble. With the object of giving all workers an opportunity of comparing notes and organising a settled plan of campaign a Conference was held at the Institute during the last strawberry fruit season. A scheme of work for the coming year has been arranged and a Special Investigation grant from the Ministry of Agriculture has been promised, if the services of a suitable full-time research worker can be secured.

In continuation of work on the cold storage of fruits, which the Institute has carried on each year since the war on behalf of the Food Investigation Board, trials have been carried out on the keeping qualities of apples from selected plantations presenting features of special interest in connection with the Fruit Soils Survey, and these will be repeated over a series of years to eliminate complications introduced by seasonal variation. The trials with soft fruits and plums are being continued as usual.

During the year Mr. Wallace has continued to serve on the Experiments Committee of the Bath and West Society, for which body work on " The Manuring of Acid Pastures " and " The Eradication of Bracken from Moorland Pastures " is in progress. Since Mr. Wallace's duties at the Research Station now relate entirely to Horticultural matters, it has been arranged that in future Dr. Hanley should undertake a considerable proportion of the field work carried out for the Society, and accordingly he was recently elected a member of the Experiments Committee. This arrangement should effect considerable economy in the time required for the work. Since the election of Dr. Hanley to the Committee, an investigation to explore the possibility of utilising economically local sources of limestone for agricultural purposes by the use of portable crushing machines and improvised kilns has been commenced. Dr. Hanley and Mr. Wallace are collaborating in the work.

Acknowledgment should be made of the services which have been rendered by the members of the administrative and assistant staffs. The part played by them in the work of the Institute cannot be adequately indicated in a Report of this character, and only those familiar with the inner working of the Station can fully recognise the importance of their share of its work and the generous measure of their contribution to its efforts.

THE EFFECTS OF LEACHING WITH COLD WATER ON THE FOLIAGE OF THE APPLE.*

By C. E. T. Mann and T. Wallace.

During the summer of 1924 observations made in the plantations at Long Ashton and in other localities in the West showed the foliage of several varieties of apples to be badly damaged by a very charactertistic form of spotting. Among the varieties on which this damage was observed were Cox's Orange Pippin,† Stirling Castle, King's Acre Pippin and Allington Pippin. The severity of the trouble ran in the order in which the above varieties are quoted, Cox being very much more seriously affected than any other variety. Such varieties as Bramley's Seedling, Newton Wonder and Worcester Pearmain were quite unaffected.

Detailed observations on the foliage of Cox's Orange Pippin showed successive stages in the breakdown of the leaf tissues. Minute purplish spots appeared in the leaf blades, which increased in size forming irregular purplish blotches. Later stages showed, in the centres of these discoloured regions, small areas of dead tissue which appeared to increase in size progressively. The purplish discolouration persisted around the margins of the areas of dead tissue and probably indicated an intermediate stage in the breakdown of the leaf cells. Series of concentric markings in the dead areas of the leaves showed that the death of the cells was not continuous, but that periods of check occurred. So serious was this damage in the field that on June 24th practically every mature leaf on certain trees of the variety Cox showed signs of the trouble and defoliation was extensive in the worst cases.

The summer of 1924 was abnormally wet; at Long Ashton in the period from May 1st to July 31st the total rainfall amounted to 13.77 inches as compared with 4.74 inches for the corresponding period in 1923. It appeared significant that the spotting trouble described should be so markedly severe in such a season.

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* The present communication is an abridged form of a paper published in Journ. of Pomo. and Horti. Science. Vol. IV. Nos. 3 & 4, 1925

† It is not intended at present to connect definitely the damage here described with the form of spotting occurring on the leaves of Cox's Orange Pippin, frequently termed "Cox-Spot."

In this connection some observations made in an independent investigation are of interest. Four series of one year old trees of Cox's Orange Pippin growing in sand cultures were prepared for different nutrient treatments. Two trees from each series were placed in a cold greenhouse and the remainder were set up in the open. On June 23rd it was noted that the foliage of the trees in the open was suffering from spotting trouble, whilst the foliage of the trees similarly treated but protected from rain was unaffected. These observations suggested that excessively wet conditions might be largely responsible for the damage described. The alternation of wet and dry periods would afford some explanation of the intermittent character of the trouble.

PART I.

To test whether the spotting effects described above could be produced on apple leaves by their alternate immersion in water and exposure to air, series of experiments were devised which are briefly described below.

A. Qualitative Experiments.

Samples of healthy leaves of the varieties Cox's Orange Pippin and Bramley's Seedling were immersed in cylinders of cold distilled water. After certain intervals of immersion corresponding samples for each variety were removed and allowed to dry off in the air, the time of exposure being also recorded. These experiments were performed in duplicate for each variety, and both detached leaves and shoots bearing healthy leaves were used.

After about one hour's immersion portions of the leaf tissue exhibited a darker green appearance due to the injection of intercellular spaces with water. This injection occurred very readily in the case of Cox, especially where the leaves had been slightly damaged before immersion. On removal of the leaves these darker green areas either regained their normal colour or turned brown.

In either case, whether the leaves of Cox were attached to the shoots or immersed singly, after a period of two hours' immersion followed by an exposure to the air of one hour, clearly defined spots or patches of brown tissue appeared in the leaf blades. Spotting of a similar nature occurred to a very slight extent on the leaves of Bramley only after a period of approximately 24 hours' immersion followed by an exposure of from three to four hours. After a similar treatment only small portions of the leaves of Cox appeared healthy.

During the course of these experiments it was noticed that the water in which the leaves were immersed became coloured, indicating that certain substances were being removed from the leaves. This

being so, it was thought that chemical analysis of the water in which leaf samples had been immersed should yield results of interest. Other workers have shown that the potassium compounds which occur in plant tissues are all readily soluble in cold water. Therefore should removal of solutes occur on immersion of a leaf in water, determinations of the amounts of potash contained in the solution after successive periods of immersion should afford figures indicative of the rate and extent of this removal.

B. Quantitative Experiments.

Three samples of healthy leaves, each of about 20 grams, were collected from trees of the two varieties, Cox's Orange Pippin and Bramley's Seedling.

The three samples for each variety were quickly weighed and treated in the following manner.

Samples 1. These were dried to constant weight at 98° C. The dry matter, total ash and the total potash (K_2O) in the ash were determined.

Samples 2. Each sample was immersed for three consecutive periods of 24 hours in a litre of distilled water and a final immersion of seven days was made. The four extracts thus obtained for each variety were evaporated to dryness, the residues "ashed," and the potash content of each extract determined. The extracted leaves were also dried to constant weight, ashed and the potash remaining in the ash determined in both cases as in Samples 1.

Samples 3. Both samples were crushed thoroughly and each immersed in a litre cylinder containing distilled water for 24 hours. At the end of this period the extracts were decanted off, filtered and evaporated to dryness. The crushed residue of the leaves was dried and the potash contents of both this material and the extract were determined.

This experiment was repeated for each variety with two samples of shoots bearing healthy leaves. The treatments followed were the same as those to which the detached leaves in Samples 1 and 2 above were subjected, analyses being made of the leaf blades and the extracts in a similar way. A summary of the main results obtained is presented in Table I, the quantities given being expressed as percentages.

Nature of the Extracts.

In these experiments the extracts were poured off, filtered and evaporated to dryness, and in every case it was found that they rapidly clogged an ordinary filter, though the extracts appeared quite clear. This fact suggested the presence of some colloidal substance, such as pectin, in the extracts. During the early stages of evaporation the extracts invariably turned brown, indicating the presence of oxidising enzymes. A characteristic smell of "apple jelly" was invariably noted during the final stages of evaporation.

Table I.

The Extent and Course of Removal of Soluble Compounds from Detached and Attached Leaves of Cox's Orange Pippin and Bramley's Seedling by Cold Water as indicated by

(i) Reduction in Dry Matter and Total Ash.

(ii) Amounts of Potash (K_2O) in Extracts and Residues.

(*a*) Detached Leaves.

Variety.	Sample.	Dry Matter as % Fresh Wt.	Ash as % Dry Matter	K_2O as % Ash	K_2O in Extracts as % Total K_2O				
					1st 24 Hrs.	2nd 24 Hrs.	3rd 24 Hrs.	4th 168 Hrs.	Total Period
Cox	1. Healthy Leaves	33.7	5.85	27.2	—	—	—	—	—
Bramley		29.7	6.03	28.64	—	—	—	—	—
Cox	2. Extracted Leaves	23.17	2.66	0.24	64.05	25.0	5.71	4.96	99.72
Bramley		22.55	3.43	1.02	11.90	15.60	20.11	38.77	86.38
Cox	3. Crushed & Extracted Leaves	20.25	3.02	3.23	96.55	—	—	—	96.55
Bramley		20.90	3.54	4.95	93.20	—	—	—	93.20

(*b*) Attached Leaves.

Cox	1. Leaf Blades of Healthy Shoots	33.16	6.23	36.49	—	—	—	—	—
Bramley		35.47	4.91	31.72	—	—	—	—	—
Cox	2. Leaf Blades of Shoots after Immersion.	—	2.84	4.34	17.81	27.57	24.72	26.90	97.00
Bramley		—	3.34	17.90	9.82	13.24	15.18	36.98	75.22

Discussion of Experimental Results.

(*a*) *Qualitative Results.*

The qualitative results recorded above show that it is possible to produce a form of spotting on apple foliage by successive immersion of the leaves in water and exposure to the air. The conditions attendant on the production of this leaf damage in the experiments described and those obtaining in the field were in many respects comparable though differing widely in degree of severity. In the field when rain is accompanied by strong winds, as was frequently the case in the summer of 1924, it is possible for leaves to be completely covered with films of water for a period of several hours. Further, in long continued rain these films are constantly changing, so that virtually the leaf surfaces are being washed with running water. The condition is thus comparable with one of immersion of the leaf in water in that a large volume of water comes into contact with the leaf surfaces. The damage further caused by wind renders possible the injection of the tissues in the damaged regions.

The results obtained with the two varieties agree well with plantation observations in which it was noted that Bramley leaves were much more " resistant " to spotting than were the leaves of Cox.

(*b*) *Quantitative Results.*

The quantitative results summarised in Table I. show clearly that certain substances may be removed from apple leaves immersed in cold water. The extent of this removal, for example, is clearly shown in the reduction in dry matter constituents approximately 26 per cent. of which were removed in the course of the experiment from detached leaves of both Cox and Bramley. The dry matter thus removed contained 67 per cent. of the ash constituents in the case of Cox and 58 per cent. in the case of Bramley. Complete determinations of the potash extracted and retained in the leaves showed that 99.7 per cent. of the total potash was removed from the leaves of Cox and 86.4 per cent. from those of Bramley.

The course of this removal is indicated in the analyses of successive extracts, and these figures show that removal is much the more rapid from the leaves of Cox.

In general the results obtained with whole shoots follow a similar course, though the rate of removal is less rapid in the case of both varieties.

Physiological Considerations.

Immersion of a healthy leaf in water exposes it to at least two processes calculated to damage the living cells comprising the leaf tissues :—

(i) A process of injection of intercellular spaces with water leading to asphyxiation of the cells in the injected region.

(ii) A process of lixiviation, or leaching out, of soluble cell contents.

These two processes are connected, since death of injected tissues, following asphyxiation, aids the rapid removal of solutes by leaching. But injection and death of injected tissues followed by the removal of cell solutes are insufficient to account for the large quantities of soluble compounds obtained in the extracts. In an experiment where shoots of Bramley's Seedling were immersed in water for 24 hours, on removal of the shoots from the water the leaves showed only slight damage. The shoots were placed with their cut ends in distilled water and the leaves remained healthy for several days, when they were finally detached for analysis. Analyses of the leaves and of the extract in which they had previously been immersed showed that approximately 10 per cent. of the total potash originally present in the leaves had been removed. The amount of dead tissue was quite inadequate to account for such a loss.

It is, therefore, clear that some other processes must be concerned, and of these a process of lixiviation or leaching seems to be the most probable. The outer walls of the epidermal layers of leaf cells are permeable to some extent and further the occurrence of the stomata render possible the entry of water to the region of thin-walled cells comprising the bulk of the leaf tissue. When a leaf is immersed in water a process of dialysis will go on, whereby diffusible substances pass through the permeable outer layers into the water. The rate and ultimate extent of this removal will depend on the degree of permeability of the surface layers and the nature of the dissolved substances.

Potassium salts are very readily diffusible, and this may account for their almost complete removal from living tissues as shown in the experiments recorded here and those of other workers. Evidence that the permeable surface layers partially control the outward passage of dissolved substances from the leaf is afforded by the experiments with crushed leaves. When the leaves were immersed whole so that only the undamaged surfaces came in contact with the water, the loss of potash from the leaves of Cox and Bramley amounted to 12 per cent. and 64 per cent. of the totals respectively, in 24 hours. When the leaves were crushed approximately 95 per cent. of the total potash was removed from the leaves of either variety in the same period. These differences indicate :—

(1) that the outer surface layer controls partially the loss of dissolved substances from the leaf ;

(2) that the degree of this control varies with the variety of apple.

Part II.

The results of the foregoing experiments, showing that soluble compounds were leached from apple leaves by immersing them in cold water, suggested that a similar process might operate under natural conditions in the field. Further, if this be so, it should be possible to compare by the methods previously described, the resistance offered by the leaves of different varieties to this leaching action. To test these two points the following experiments were performed :—

I.—Four samples of leaves were collected from trees of the variety Cox's Orange Pippin, and the potash content of the ash of each sample was determined.

The ash from a sample of healthy-leaves yielded 36.5 per cent. of potash. The second sample, which comprised leaves showing stages of purplish discolouration but no dead tissue, contained only 22.1 per cent. of potash in the ash. These results indicate that the removal of soluble substances from the leaf occurs before the actual death of the tissues and not as a consequence of the death following a previous damage. The ash of a third sample of leaves, showing a moderate amount of dead tissue, contained 19.7 per cent. of potash, whilst the ash of badly affected leaves contained only 13.4 per cent. These results show quite definitely that soluble substances may be removed from leaves under natural conditions. The disappearance of potash from the leaves must be explained either by

(*a*) its withdrawal into the plant internally ; or

(*b*) its removal from the leaves and loss to the plant externally.

The fact that loss from the leaves occurred at a time when conditions were favourable for the passage *into* the leaves of water and dissolved substances seems to send the balance of evidence in favour of the first suggestion, which is strongly supported by the experimental results recorded in Part I.

II.—In order to compare the differences in the resistance of the leaves of certain apple varieties to the leaching action of water, healthy shoots were collected from trees of the following :—Cox's Orange Pippin, Allington Pippin, Bramley's Seedling, James Grieve, Newton Wonder and Worcester Pearmain. The procedure followed was similar to that employed in the experiments with attached leaves described in Part I.

Lack of space prevents the inclusion here of the complete record of experimental results obtained, but the course and extent of the removal of potassium compounds from the leaves of the several varieties is graphically represented in the accompanying figure (Fig. 1).

It is clear from this figure that the course of potash removal is the same in each case, which indicates that the same processes are operating throughout. The extent of this removal is shown to differ between wide limits in the varieties investigated, and it is significant that the least resistance to leaching is exhibited by the

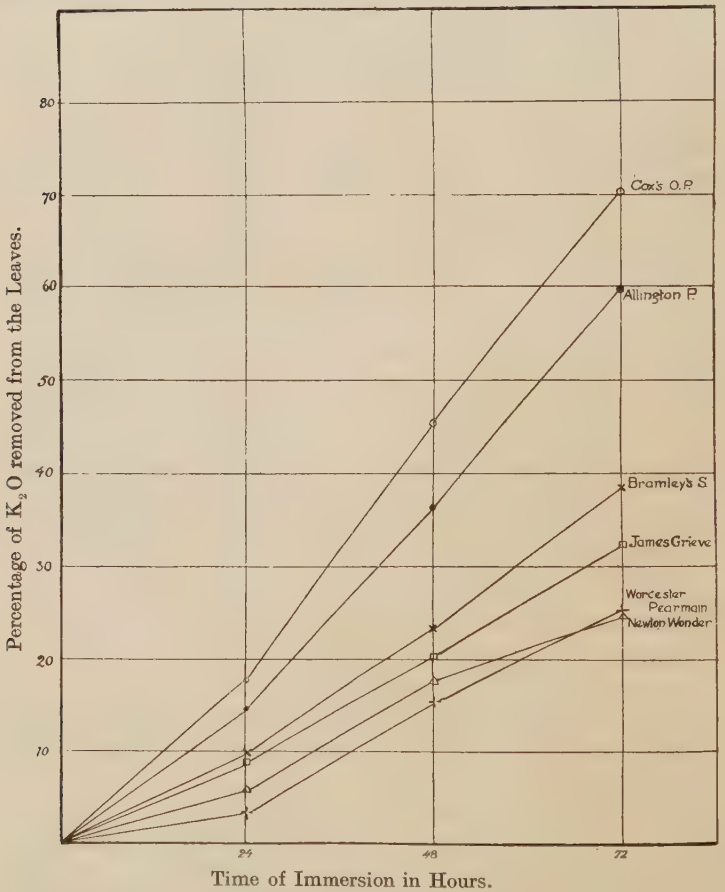

FIG. 1. The course and extent of removal of Potassium compounds from attached leaves of different varieties of apple by immersion in cold water.

two varieties which were most seriously affected with the spotting trouble in the field. The differences obtained must not, however, be interpreted as indicating the order of varietal resistance. Before such an order can be established it will be necessary to experiment with trees of the same age on the same stocks under similar cultural conditions. These points are at present under investigation.

INVESTIGATIONS ON CHLOROSIS OF FRUIT TREES—I.*

By T. Wallace and C. E. T. Mann.

The Composition of Apple Leaves in Cases of Lime-induced Chlorosis.

Introduction.

The investigations on the chlorosis of fruit trees which are being carried out by the writers, have been undertaken as a section of their studies on the wider problem of "The Nutrition of Fruit Trees."

The scope of the investigations is limited to the study of so-called accidental chlorosis—that is, to chlorosis in trees which normally are not chlorotic in which the chlorotic condition is the result of environmental factors such as particular soil conditions.

The work up to the present has proceeded along three main lines, viz.:—

1. The occurrence of chlorosis in relation to soil conditions.
2. Chemical investigations on the foliage of chlorotic trees.
3. Experiments with a view to the control of the condition in the field.

In this communication it is proposed to present certain results which have been obtained in 2.

The results of our investigations under 1 and 3 will be dealt with fully in later papers, as although some very definite progress has been made to date, further data are required to permit of definite conclusions being drawn.

In presenting the results obtained on the composition of apple foliage in the present paper, it will first be necessary to present certain soil data, and to refer to certain experimental treatments in order to show clearly the conditions with which chlorosis was associated in the particular cases under consideration, and to indicate the treatments by which green foliage was produced in other cases on trees which had previously been chlorotic.

The foliage which has been examined has been obtained from apple trees growing at five different centres. These centres were

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selected from a fairly large number which have been under observation, as providing suitable material for the work.

Soils of the Chlorosis Centres.

In Table I. are given details relating to the Geological Formations from which the soils are derived, and to the amounts of carbonates—calcium carbonate, except at Centre A.—contained in the soils at various depths.

TABLE I.

Soil Data from Chlorosis Centres.

Centre.	Surface or Subsoil etc.	Geological Formation.	Total Carbonates in air-dried soil (reckoned as $CaCO_3$) %
A.	Surface	Dolomitic Conglomerate	25.33
B.	Surface	Keuper Marl	11.86
	Subsoil	,, ,,	19.92
	18ins. to 30ins.	,, ,,	19.58
B.	Surface	Keuper Marl	6.08
	Subsoil	,, ,,	3.77
C.	Surface	Lower Lias	14.85
	Subsoil	,, ,,	9.92
D.	Surface	Chalk	69.0
E.	Surface	Inferior Oolite	18.40

It will be noted in the Table that all the soils contain high percentages of carbonates, which is the soil feature usually associated with chlorosis. Though other soil features are found to be associated with the condition (4, 5), so far as we are aware the presence of a high percentage of carbonates is by far the most common feature associated with chlorosis of trees in this country. Indeed, our soil investigations have led us to the conclusion that there is a large element of risk attaching to the planting of fruit trees on either chalk or limestone formations in this country, as although the quality of the fruit from such plantations is almost invariably excellent, the trees generally succumb prematurely to chlorosis, and in certain cases fail entirely to become established. At the centres considered in this paper, the trees have failed conspicuously, and it has been obvious that the soil conditions are quite unsuited for the growing of trees under the cultural methods usually followed in fruit plantations.

From certain results which we have obtained in our experimental treatments of the trees, it appears that it will be possible to grow

trees free from chlorosis on certain of these soils by the use of special methods.

The following notes are included to supplement the data presented in Table I.

Centre A.—The Geological Formation from which this soil is derived is not generally utilised for commercial fruit growing. The formation is fairly extensively developed in Somerset, and the soil generally exerts a marked toxic action on trees which invariably show symptoms of chlorosis. Cases of chlorosis on this formation have been discussed in a previous paper by one of us. (6).

The underlying rock at this centre is Dolomitic in character, and the soil is generally shallow and stony, the stones consisting of pieces of Dolomitic limestone. The surface soil sample taken for analysis contained 34.6% of these stones.

Centre B. The soil at this centre varies greatly over quite small areas in the amount of carbonate found, as the carbonate is derived from small bands of limestone known locally as "skerry." It was shown by sampling, that only the trees in the vicinity of these outcrops developed chlorosis. Thus, in certain areas of the plantations the carbonate content in successive 9in. samples from the surface down to 27ins. was of the order of 0.1%, whilst at the points near the outcrop the amounts shown in the table were found. Up to the time when the plantations were first visited, on the former of these areas, and on the area for which the data are presented in Table I, in which the carbonate content of the surface soil was 6.08%, the trees had made excellent growth, and were entirely free from chlorosis. During the same period, the trees on the area showing 11.86% of carbonate in the surface soil were extremely chlorotic, and had failed to make healthy growth.

Centre C. The carbonate content of the soil at this centre is variable in patches, depending on the proximity to the surface of bands of lias limestone which underlie the clay soil. In addition to the naturally occurring carbonate, the amount in the surface soil has been considerably augmented by the application of dressings of lime.

Centre D. This soil is a thin bare chalk soil, the underlying chalk rock often occurring at a depth of 9ins.

Centre E. The soil is a typical brashy oolite soil, containing a large percentage of oolite "stones" and having the underlying limestone rock at depths varying from a few inches.

The data provided in Table I, together with the foregoing notes will suffice to show that the cases of chlorosis considered are typical cases of so-called lime-induced chlorosis, in which the occurrence

of the chlorotic condition is associated with high contents of carbonates in the soil.

Chemical Data on the Foliage.

The analytical data obtained on the foliage are reported in Table II, and the following notes on the samples are added in elaboration of these to show the sources of and the particular circumstances under which the samples were collected.

TABLE II.

RESULTS OF ANALYSIS OF LEAF SAMPLES OF APPLE FROM CHLOROSIS CENTRES.

Sample No.	A.	A.1.	A.2.	A.3.	A.4.	A.5.	B.	B.1.
Variety. Condition of leaves Date of taking samples.	Wellington Green 27/7/23	Wellington Chlorotic 27/7/23	Wellington Green 9/7/25	Wellington Chlorotic 9/7/25	Wellington Green 4/9/25	Wellington Chlorotic 4/9/25	Lane's Prince Albert Green 24/7/24	Lane's Prince Albert Chlorotic 24/7/24
	%	%	%	%	%	%	%	%
Dry Matter	—	—	34.59	29.65	37.43	32.94	—	—
Ash in Dry Matter ..	9.47	12.60	10.87	11.69	9.74	9.12	9.76	13.40
Fe_2O_3 in ash	—	—	1.17	0.62	0.33	0.12	0.34	0.59
Al_2O_3 „	—	—	1.22	1.39	0.05	0.34	—	—
CaO „	31.60	20.42	35.51	22.54	28.65	16.27	30.72	13.27
MgO „	3.89	4.48	7.00	5.95	5.15	4.45	6.59	5.97
K_2O „	30.02	32.57	17.57	28.12	19.64	39.26	16.32	39.11
Na_2O „	—	—	—	—	9.29	13.35	—	—
SiO_2 „	0.29	0.32	0.98	2.60	2.71	4.61	—	—
P_2O_5 „	3.57	4.49	3.57	3.76	2.17	3.72	4.99	4.67

TABLE II (*Continued*).

Sample No.	B.2.	B.3.	B.4.	B.5.	C.	C.1	C.2.	C.3.
Variety.	Lane's Prince Albert Green	Lane's Prince Albert Green	Lord Grosvenor Green	Lord Grosvenor Chlorotic	Monarch Green	Monarch Chlorotic	Monarch Green	Monarch Chlorotic
Condition of leaves.	(Shoot leaves)	(Spur leaves)						
Date of taking samples.	22/9/25	22/9/25	22/9/25	22/9/25	13/6/25	13/6/25	4/9/25	4/9/25
	%	%	%	%	%	%	%	%
Dry Matter ..	38.46	39.60	39.09	31.71	31.92	23.86	38.18	27.92
Ash in Dry Matter ..	8.62	9.98	9.68	11.59	7.90	9.49	9.18	11.96
Fe_2O_3 in ash	0.15	0.02	0.15	0.26	0.69	0.59	1.07	0.04
Al_2O_3 ,, ...	0.10	0.11	0.29	0.09	—	—	0.09	0.07
CaO ,, ...	29.90	28.50	23.83	14.04	11.92	5.86	22.75	14.53
MgO ,, ...	8.47	7.12	8.99	5.65	5.50	5.25	5.55	5.40
K_2O ,, ...	17.07	11.19	17.14	34.91	28.05	44.66	22.67	40.89
Na_2O ,, ...	22.85	22.42	17.46	20.21	—	—	8.09	12.60
SiO_2 ,, ...	4.66	5.75	2.63	1.59	1.51	2.77	3.21	3.02
P_2O_5 ,, ...	3.55	3.55	3.80	4.95	8.54	9.85	3.02	4.47

TABLE II (*Continued*).

Sample No. Variety. Condition of leaves. Date of taking samples	D. Worcester Pearmain Green 6/6/25	D.1. Worcester Pearmain Chlorotic 6/6/25	E. Lane's Prince Albert Green 4/9/25	E.1. Lane's Prince Albert Chlorotic 4/9/25
	%	%	%	%
Dry Matter	32.83	28.46	39.95	38.06
Ash in Dry Matter ..	7.41	10.70	10.72	13.64
Fe_2O_3 in ash	0.64	0.49	0.19	0.14
Al_2O_3 ,, ...	—	—	0.17	0.19
CaO ,, ...	15.40	7.02	32.13	24.98
MgO ,, ...	4.19	6.57	6.25	4.70
K_2O ,, ...	35.24	44.08	14.34	—
Na_2O ,, ...	—	—	9.79	—
SiO_2 ,, ...	2.28	3.17	2.76	3.45
P_2O_5 ,, ...	10.84	9.20	3.91	4.31

Samples A.—A.5.

Samples A.—A.5 were all taken from the same tree, which was growing in a garden under good cultural conditions, and which had received generous manurial treatment. In 1925 it was about 12 years of age, and had shown symptoms of chlorosis for several years. During the seasons of 1923 and 1924, practically the whole of the foliage was markedly chlorotic, and in the latter season the fruits borne had the appearance of wax models and were without any trace of green colour. A portion of the foliage was sprayed with a solution of sulphate of iron in 1924, and the spraying was repeated over the whole of the foliage in June, 1925, following which, it was exceedingly difficult to obtain samples of chlorotic leaves from off the tree on the two dates given in Table II—July 9th and September 4th.

Samples B.—B.5.

Samples B. and B.1 were taken on the same date, the former from healthy trees about 10 years of age growing on an area as shown in Table I, where the surface soil contained 6.08% of carbonate, and the latter from strongly chlorotic trees, 5 years of age, which had failed to make healthy growth, growing on an area as in Table I, where the surface soil contained 11.86% of carbonate.

Samples B.2 and B.3 were taken from the same trees as Sample B.1 during the following season, during which season the trees were subjected to "grassing down" treatment, following which chlorosis was entirely absent, and the trees bore normally green foliage and a medium crop of normal fruits.

Samples B.4 and B.5 were from trees of a different variety, about 10 years of age, growing under the same soil conditions as the B.1 trees, clean cultivation being practised.

The tree from which sample B.4 was taken had been sprayed earlier in the season with sulphate of iron solution which had resulted in the partial disappearance of the chlorotic condition, whilst the tree from which sample B.5 was taken had been left unsprayed and the foliage had remained strongly chlorotic.

Samples C.—C.3.

Samples C.—C.3 were from young 3 year old standards growing in a nursery. Samples C and C.2 were from certain of the trees which had been sprayed with sulphate of iron solution earlier in the season, which treatment had greatly checked the development of chlorosis.

Samples C.1 and C.3 were from control trees which had received no spraying treatment, and which were strongly chlorotic, many being in a crippled condition.

Samples D.—D.1.

The trees from which these samples were taken were about 7 years of age and were growing side by side in the middle of an area on which the majority of the trees were markedly chlorotic, only occasional trees retaining a proportion of green foliage.

Samples E. and E.1.

The trees from which these samples were taken were 4 years of age. Those bearing chlorotic foliage had been sprayed earlier in the season with a solution of sulphate of aluminium, which treatment had been ineffective in checking the development of chlorosis. Those bearing the green leaves had not received any special treatment.

In the following discussion the data on certain samples will be compared in order to bring out certain differences obtaining in the composition of green and chlorotic foliage.

In the collection and preparation of samples for analysis, every precaution was taken to ensure that the results would allow of comparisons being made. All samples were collected into air-tight tin boxes and were usually in process of analysis within a few hours after picking; where any delay occurred dry matter percentages were not taken. Prior to analysis all petioles were removed, the data thus referring only to the laminae of the leaves.

Discussion.

From the data presented in Table II, the following comparisons of green and chlorotic foliage may be made :—

Samples A. with A.1.; A.2. with A.3.; A.4. with A.5.; B. with B.1.; B.1. with B.2. and B.3.; B.4. with B.5.; C. with C.1.; C.2. with C.3.; D. with D.1.; E. with E.1.

In making these comparisons, attention is drawn to the following :

Samples A.—A.5 allow of comparisons between green and chlorotic leaves growing on the same tree in two different seasons, and on three different occasions.

Samples B. and B.1 provide data for comparison between green and chlorotic leaves from trees of different ages, growing on the same soil, but with the soils containing different amounts of carbonates.

Samples B.1, B.2, and B.3 allow of comparisons between green and chlorotic leaves from the same trees in different seasons, the green leaves having been developed following " grassing down "

treatment. B.1 was a composite sample of leaves from shoot and spur growths.

Samples B.4 and B.5 admit of comparison of green and chlorotic leaves from trees of similar age, the green colour having resulted from sulphate of iron treatment.

Samples C.—C.3 provide data for comparison of green and chlorotic leaves from two batches of trees of similar age on two occasions following the treatment of one batch with sulphate of iron spray, which markedly reduced the amount of chlorosis.

Samples D. and D.1 allow of comparison of green and chlorotic leaves from trees growing under soil conditions which appeared to be strongly conducive to chlorosis, which conditions certain of the trees appeared at that time to resist.

Samples E. and E.1 admit of comparisons between green and chlorotic leaves from young trees of similar age, growing under similar soil conditions, and where spraying with sulphate of aluminium had failed to reduce the amount of chlorosis.

In making the above comparisons, four points stand out in very striking fashion.

1. The percentage of dry matter present is, in all cases, appreciably higher in the green leaves than in the chlorotic leaves.
2. The ash in the dry matter is higher in the chlorotic leaves than in the green leaves in all cases excepting one—A.4 with A.5—in each case the difference is only very small.
3. The percentage of calcium is, in all cases, markedly lower in the ash of the chlorotic leaves than in that of the green leaves.
4. The percentages of potassium and sodium are always much higher in the ash of the chlorotic leaves than in those of the green leaves ; especially is this so in the case of potassium, which may show an increase of 100% in the chlorotic over that of the green in comparable samples.

Other points which require mention are as follows :

1. The percentage of iron reckoned as Fe_2O_3 contained in the ash of green leaves is not always larger than that of the ash of the chlorotic leaves. The data recorded do not throw much light on this point owing to the complication introduced by the sulphate of iron treatment. Comparison of Fe_2O_3 in samples B.2 and B.3 shows that very large fluctuations in iron may occur normally in the ash of green leaves.

2. The data for the amounts of aluminium are not regarded as showing significant differences in either direction owing to the difficulties of estimating this element in samples of ash.

3. The percentages of magnesium are generally higher in the ash of the green leaves than in that of the chlorotic, but there are two cases in which the reverse is the case.

4. The silica content is higher in the ash of chlorotic leaves in six cases, and in that of the green leaves in two cases. The former differences are generally large, as also is one of the latter.

5. The percentage of phosphorus is higher in the ash of the chlorotic leaves in seven cases, and in that of the green leaves in two cases.

The results recorded here for calcium and potassium do not agree with those of several other workers on lime-induced chlorosis, whose results are reported by Gile and Carrero (3). These workers have generally found higher percentages of calcium and either similar or lower percentages of potassium in the ash of chlorotic leaves than in that of green leaves. They are, however, similar to those reported by Colin and Grandsire (2), and by Church (1) in carrying out similar studies on congenital chlorosis or albinism. These workers found that the salient points of difference in composition between green and chlorotic leaves of the chestnut, elm and other plants in cases of albinism were the higher dry matter content in the green leaves, the higher ash percentage in the chlorotic leaves, and the higher calcium content and correspondingly lower potassium content of the ash in the green leaves.

Summary.

1. The results of an investigation on the composition of green and chlorotic leaves in some typical cases of lime induced-chlorosis of apple are reported.

2. Soil data are presented to show the nature of the soil conditions which were conducive to chlorosis in the cases considered.

3. Data on the composition of green and chlorotic leaf samples are provided, from which it is possible to make comparisons under various conditions.

4. The data show that the salient differences in the composition of green and chlorotic leaves in all cases are as follows :

a. Green leaves contain higher percentages of dry matter, and lower percentages of ash in the dry matter than do chlorotic leaves.

b. The calcium content of the ash of the green leaves is much higher than that of chlorotic leaves.

c. The percentages of potassium and sodium—especially potassium—are much higher in the ash of chlorotic leaves than in that of green leaves.

d. The differences in the amounts of magnesium, iron, aluminium, phosphorus and silica are not so definite in character as in the cases of calcium, potassium and sodium.

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PROGRESS REPORT ON FRUIT BREEDING.

By G. T. Spinks.

The work on this subject has been continued on the lines indicated in the Reports of 1920 and 1921. Since that time fewer new seedlings have been raised, and they have mainly been produced by the repetition of previous crosses, in order to increase the size of certain families of seedlings ; but a few new combinations of parents have also been tried.

The chief work, however, has been the observation of existing seedlings and the selection and propagation of those which seemed likely to be of value. The progress of the work with the various fruits is summarised below :—

Apples.—There are now in the plantations about 1,800 seedling apples, of which about 700 are the product of open-pollinated seed ; that is to say, only the female parents of these are known. The remaining 1,100 seedlings are the result of controlled pollinations and are mainly crosses, though in a small number of cases the female parent was self-pollinated. Some of the earlier seedlings were grafted on Type 1 Paradise stock, others have been worked on more dwarfing stocks, such as Types 8 and 9, while a number have been head-worked on older bush trees. All the seedlings produced during the last few years, however, are being grown on their own roots, planted closely and given a minimum of pruning.

Up to the present only about 30 of these seedlings have fruited ; but a number of these fruited for the first time this year, and probably quite a large number will now be coming into bearing in each succeeding year. Many of the fruits, as is only to be expected, seem to be quite worthless, and none of outstanding merit have yet appeared, though two or three may be worth propagating for a more extensive trial. Descriptions of the fruit of each seedling are being kept, in addition to notes on the trees themselves.

In the last few years one or two of the bearing trees have been crossed back with one or both of their parents, and a second generation of seedlings is now being raised. In some cases they have been self-pollinated, but usually no seed has been produced by this method.

Pears.—About 150 seedling pears are now being grown. They are all the result of crosses, and there are three fairly large families and two small ones. All the trees are growing on their own roots,

and none have fruited yet, the oldest of them having now made five years' growth from the seed.

Plums.—The number of plum seedlings now growing is about 150. Attempts to increase the size of a few families of crosses are still being made, but the numbers are only increasing slowly as the successful fertilization of a plum blossom produces only one seed, and the number of seedlings finally raised is often small compared with the number of blossoms pollinated. With the exception of a few of the earliest seedlings produced, which have been worked on stocks, all the plums are growing on their own roots. None of them have fruited yet. All these plum seedlings are the result of crosses or of self-fertilizations.

Black Currants.—The earlier selected black currants have been propagated in order to test the cropping of a number of bushes of each seedling variety, but the bushes are not yet bearing. The plantation of 1,300 seedlings produced by various crosses between five well-known types of black currant, has now cropped for two years. Observations on all the bushes and selections of promising ones have been carried out during the last two years, and will be continued next year. It has been easy to select a number of good bushes, but none of outstanding merit have been found. Probably it will be necessary to propagate and test on a fairly large scale quite a large number of these seedlings, say about 30, in order to find out with certainty which are the best.

The only production of new seedlings during the last few years has been from a cross between the variety Baldwin and one of the Boskoop group. The seedlings are at present only one year old from the seed.

Gooseberries.—No new gooseberry seedlings have been raised for some years past. Approximately 400 are now growing in the plantations, but only about 100 of these have yet begun to crop freely. Notes are being made of the characters of all these bushes, and any of marked promise will be propagated for further trial. So far only one has justified selection.

Raspberries, Blackberries and Hybrid Rubi.—Some of the raspberry seedlings which in former years appeared very promising have been rather disappointing. They have not been grown hitherto in large numbers or under very good conditions, owing to lack of available land; but now a few of the best have been included in a fairly large-scale trial of commercial varieties, and a truer idea of their value should soon be obtained.

A few crosses between some of the most successful varieties of raspberries have recently been made, but none of the seedlings have fruited yet.

Very many raspberry seedlings have been discarded as useless, and this has also been done with many selfs and inter-species crosses of raspberries, loganberries, blackberries, etc., as very few were of any value. One cross, however, between the Himalaya Berry and an autumn-fruiting raspberry, has produced some interesting results. Two first generation hybrid plants were obtained, and from open-pollinated and selfed seed of these a number of second generation seedlings have been grown. These vary a great deal in character, and many of them are useless, though interesting; but a few bear good crops of fruit of distinctive character. The flavour is not particularly good, and the berries often will not part cleanly from the stem, so that these types in their present form do not appear to be of much commercial value. But they appear well worth further investigation, and accordingly have been re-crossed with raspberries, loganberries and blackberries in the hope that some better new form of berry will be produced. This last generation of seedlings has not yet reached the fruiting stage.

A few seedling loganberries, which may possibly be an improvement on the usual type, are being propagated for further trial.

The seed of some selected wild blackberries has produced some very good plants. Each of the wild varieties seems to have bred very nearly, if not quite, true. A few plants which appear to be slightly better than the rest have been selected for propagation, so that true clones will be available for trial. These varieties of blackberries bear heavy crops of large, attractive, good-flavoured berries which ripen considerably earlier than most wild varieties; they therefore seem likely to have some commercial value.

Strawberries.—Since the publication in the 1923 Report of the Notes on Strawberry Breeding, few new seedlings have been raised.

The new seedlings are mainly the result of the repetition of crosses which had been found to produce a large proportion of good seedlings, though only small families had previously been raised. A few F_2 families have also been obtained by selfing selected seedlings. A family of seedlings from the cross King George × Grove End Scarlet has been raised in the endeavour to produce a good jamming berry. Most of these new seedlings have not yet fruited, and those which have fruited do not include anything of special interest.

Seedlings raised in former years and fruiting for the first, second or third time have been the subject of observation and selection. Other seedlings previously selected and propagated have undergone a further process of elimination, many being discarded, while others have been selected for further trial. About 100 seedling varieties

which have been propagated are still under trial, though the majority of these have only reached the stage where there are five plants of each variety ; but others are being tried in twenties and hundreds. These selected varieties include plants of all seasons, and kinds thought to be suitable for jam are included as well as dessert varieties.

PROGRESS REPORT ON APPLE ROOT STOCK INVESTIGATIONS.

By G. T. Spinks.

On the last occasion on which these investigations were dealt with in the Annual Report, viz., in that for 1917, it was stated that it was probable that there would be little of material interest to report upon for some years, since they would be mainly occupied with propagation of the selected root stocks to secure numbers of each sufficiently large for the programme of trials. This propagation phase of the investigation is now drawing to a close, and a start is being made with the trials proper. This forms, therefore, a convenient occasion to summarise the work so far as it has progressed since the last account of it was given.

It should be recalled that in 1913 the Research Stations at East Malling and Long Ashton arranged a joint investigation of apple root-stocks, and while the East Malling Station proceeded to examine the " Paradise " stocks this Station undertook the study of " free " and " crab " stocks. In the Long Ashton Report for 1917 an account was given of the Long Ashton studies of the root-systems of a large number of seedling stocks. As a result of that examination the stocks were divided into classes, each of which seemed to have a characteristic type of root-system. At the same time it was found that a number of stocks showed signs of producing adventitious roots very readily, and it was thought that they could probably be propagated by layering. Stocks of this apparently free-rooting type appeared in most of the classes.

A selection of stocks was then made containing several representatives of each class, most of those chosen being also apparently likely to root freely. In all, about 60 stocks were selected for further study.

During the next two or three years these stocks were grown on and attempts were made to propagate them by "stooling" or "layering." It was found that some were only propagated with difficulty, and these were discarded. Others were discarded on account of their thorny character, which made them unsuitable for nursery operations. Ultimately it was decided that seventeen of the selected stocks should be propagated for further trial. A larger number were quite suitable for this purpose but, in order to prevent trials becoming

unwieldy, it was necessary to cut down the numbers as far as possible while retaining sufficient representatives of the different classes of stock.

It was found that layering was the most convenient method of propagating the stocks, and it has been quite successful with most of the selected forms. However, as each stock was, after its selection, simply one individual plant, a number of years were required in which to establish productive stool-beds of each stock. It was not, therefore, until 1923 that enough young plants of each stock were available for working with a market variety of apple in order to start a trial of the influence of the stocks.

In 1923 all the available young stocks were budded with the variety Lane's Prince Albert.

In 1924 and 1925 stocks have been worked with Worcester Pearmain, James Grieve, Newton Wonder, Blenheim Orange and Bramley's Seedling.

The different stocks vary in strength, and it is proposed to use the 12 weaker kinds of stock for a trial in which the trees will be grown in bush form in cultivated ground. The varieties to be used in this trial are Lane's Prince Albert, Worcester Pearmain and James Grieve. Trees of the same varieties worked on Type 2 Paradise stock are being used as " controls " in this trial. Some trees on the stronger stocks of the series are also being included in this trial, but Lane's Prince Albert is the only variety worked on these stronger stocks, the other two being regarded as too vigorous.

One of the objects of testing these layered " free " stocks is to find, if possible, a stock which is suitable for the production of standard trees and is also capable of being propagated by vegetative means. If this can be found standard trees can then be provided on uniform stocks, even as smaller trees are grown on uniform dwarfing stocks. Therefore the eleven stronger stocks of the series are being used for a trial of standard trees of the varieties Worcester Pearmain, Newton Wonder, Blenheim Orange and Bramley's Seedling. Standard trees grown on Type 12 " Paradise " are being included in this trial as a " control." This trial is arranged in duplicate with the trees under clean culture and in grass respectively. Some of the series of stocks are included in both the bush and the standard trials, as the relative strength of all the stocks is not yet known with certainty.

The first part of the trial plantations was planted out in November, 1925. This consisted of eight two-year-old trees of Lane's Prince Albert on each of the stocks, all the trees being planted 15ft. apart. The plot was checker-boarded so as to distribute each stock as evenly as possible over the area and thus to minimize errors due to

differences in the soil. The trees had been cut down as maidens in the nursery to form bush trees on a uniform length of leg. The trees on each stock which were planted out were selected as being as uniform and representative of the trees on that stock as could be found in the nursery. Adjoining plots will be planted up next winter with two-year-old bush trees of Worcester Pearmain and James Grieve.

Meanwhile, in the nursery, trees of the other varieties named above are being run up to form standards and will be planted out, probably when four years old, when good heads are formed.

Records of each tree are being kept from the time the stock is planted in the nursery. These include various weights, measurements of growth, and amount of blossom and crop.

The number of trees on each stock in the bush trial already started is small, but is unfortunately limited by the amount of land available. The records which are being taken in the nursery on larger numbers of young trees may give enough information before planting-out time to justify the omission of some of the stocks from further trials, and thus allow larger numbers of trees on each selected stock to be included. It is hoped in any case to arrange series of duplicate trials at other centres so that the cumulative results may provide conclusions of greater certainty than the limited initial trial will allow.

The lifting of the Lane's Prince Albert trees from the nursery for planting out has afforded an opportunity for examining their root-systems. As far as can be seen at present the type of root-system on some of the stocks appears to differ to some considerable extent from that noted on the parent plants from which they originated. This point will need further investigation when more trees are lifted.

Seedling Stocks.

The view is held by some that a layered stock will never be as suitable as a seedling stock, grown from a pip, for the growth of a large standard tree. Some further, are strongly of opinion that even a seedling " free " stock is unsuitable for this purpose and that a seedling from a " true crab " is required. These points cannot be proved or disproved on existing evidence, but it is clear that in spite of this it must not be assumed that seedling stocks could or should be entirely discarded in favour of layered stocks. Seedling stocks can be more easily and cheaply produced than layered stocks. There is some evidence, too, that differences in stock influence amongst seedling stocks are often largely obliterated by the influence of the scion variety and the conditions under which trees are grown.

It seems, therefore, desirable that the possibilities of seedling stocks should be explored at the same time as those of layered stocks, and one of the main points to be considered is the degree of uniformity which can be obtained in seedling stocks. Several experiments designed to test this point are now in progress.

Methods by which greater uniformity may be obtained appear to be :—

(i) The use of seed from known parents, preferably from trees, if any can be found, which will breed true from seed.

(ii) Grading the seedling stocks, especially as regards size and the character of the root-system.

The first experiment at Long Ashton on this aspect of the root-stock problem has consisted in the use as stocks of about 120 apple seedlings which had been raised from the seed of seven different varieties of apple, the seedlings from each variety being kept separate. All these seedlings were grafted at the same time with one variety of apple, Stirling Castle. The size of the individual stocks was noted, and later, when the young trees were planted out, the character of the root-system of each. It is intended that the trees shall receive the treatment they would receive at the hands of a good grower. Each tree is to be treated according to its merits, no attempt being made to give absolutely uniform treatment to each tree. General observations are being made on the growth of the trees from time to time. The trees, which are being grown as bushes, were planted in a permanent plantation when two years old, and are now four years old.

In a second experiment 150 miscellaneous "free" stocks are being employed. These are stocks of unknown parentage, bought from a raiser of stocks. Before planting in the nursery they were graded in respect of their size and the character of their root-systems. They have all been budded with Bramley's Seedling. The resulting trees will all be kept under observation in the nursery, and as many as possible will afterwards be planted out and will be the subjects of further records.

A third experiment is being carried out with seedlings from several varieties of crabs which appear to breed fairly true, at all events when growing in isolated situations. Up to the present only one variety of seedling crab has been worked. The seedlings have been treated as in the previous experiment. The stocks when worked appeared, with a few exceptions, very uniform in character, though they varied considerably in size. Seedlings from a second variety of crab are now ready for transplanting and grading and will be worked

later. Seed of other varieties of crab is being sown, and will provide further batches of seedlings.

It will readily be seen that one of the chief difficulties in carrying out these experiments is the large number of trees necessary, and consequently the large area of land required, in order to obtain significant results. It is also obvious that experiments with standard trees require many years for their completion, and that the land occupied by them is unavailable for other purposes during that period. The scale upon which they can be conducted will thus depend upon the resources at the disposal of the Station.

STUDIES IN THE ROOT AND SHOOT GROWTH OF THE STRAWBERRY IN SEASON 1924-25.

By E. Ball and C. E. T. Mann.

I. Introduction.

Of late Strawberry troubles have come into prominence, and very little is known of the causes lying behind the production of abnormal Strawberry plants. When the present series of investigations was commenced, certain abnormal forms of the plant were ascribed to an eelworm (*Aphelenchus fragariæ*) (See Ballard and Peren).* Further work was needed to confirm these conclusions, and in addition other forms of diseased or abnormal plants were observed in the field which showed none of the symptoms regarded as being due to the presence of *Aphelenchus fragariæ*. In July 1924 certain plants at Long Ashton were noticed to wilt rapidly and later the foliage became brown and died. On examining some of these plants certain brown patches could be seen on the roots, and there seemed the possibility that some fungus was the cause of the condition. The questions naturally followed as to how much root a Strawberry plant of a given age should have, whether any of the roots died annually, and if so how many, and at what season were new ones produced. In addition some information was required about the point of origin of the new roots. On examining several three-year-old plants in the field, it was noticeable that the vigour of the plant was often associated with the degree of contact between the crowns and the soil. Plants, the crowns of which were not in contact with the soil, were generally much inferior in vigour to those which had soil well up to the level of the new crowns.

Besides the value of a knowledge of the normal annual cycle of root and shoot growth of the Strawberry to the investigator of pathological conditions, it should be of some service to the grower himself in connection with manurial and cultivation practices. For these reasons the investigation of the growth of the root and shoot of the normal Strawberry plant, and of some of the factors likely to influence the normal cycle, was commenced by the writers

* Ballard, E. and Peren, G. S. "Red Plant in Strawberries and its correlaation with Cauliflower Disease." Journ. Pomol. and Horti. Sci. 3. 142-147, 1922.

in the autumn of 1924. In presenting an account of the work done in the season 1924-25, they do not wish the reader to infer that they would suppose that exactly the same results would be obtained in another locality or in another season, in which the general meteorological conditions were very dissimilar to those of 1924-25. This account only purports to be a progress report, but it is thought that the results so far obtained are of sufficient value to merit immediate publication. The work will be continued for several seasons, in which more than one series of plants will be examined throughout three growing seasons—the usual length of life of a Strawberry plantation. This will give the opportunity of confirming the results of one season by those of another and at the same time ascertaining something of the seasonal effect. In addition the results will be checked by observations on plants growing under conditions of soil and climate different from those prevailing at Long Ashton.

II. General Plan of Investigation.

(1) The desirability of a more precise knowledge of the behaviour of the strawberry plant, both above and below ground, has already been emphasised. The first portion of this investigation therefore consists in tracing the life history of the cultivated strawberry from the date of planting the runner through three consecutive seasons. An attempt will be made to correlate definite features in the normal, annual sequence of the development of the plant with the meteorological factors of rainfall, sunlight and soil temperature.

(2) The second portion of this investigation is designed with the object of discovering the effects of certain factors, other than meteorological, on the normal sequence of events. The particular factors to be investigated are the effects on the subsequent development of the plants of :—

(*a*) Cropping of maiden plants.
(*b*) Time of planting runners.
(*c*) Different methods of planting, *e.g.* :—
  (i) Deep planting.
  (ii) Shallow planting.
  (iii) Differing degrees of root trimming previous to planting.
(*d*) Various methods of cultivation.

(3). Finally, abnormal plants are to be examined with a view to finding whether the observed abnormalities can be attributed to defective root systems.

The plants used throughout the work in Sections (1) and (2) were obtained from a good strain of the variety Royal Sovereign, except in one instance, viz., in the time of planting experiments the runners planted in October were of the variety, Sir Joseph Paxton.

III. Methods.

The methods employed in this investigation have already been fully described in the Journal of Pomology, and therefore only a brief outline is given here.

Approximately fifteen hundred runners provided the necessary material for the experiments, and as far as possible Royal Sovereign was the variety employed.

1. In following the normal development batches of ten plants were carefully lifted and washed at intervals of from three to six weeks from the date of planting, September 2nd, 1924, till September 16th, 1925. The necessary observations on root and shoot growth were made, and quantitative data were also obtained on the weights of roots and crowns.

2. (*a*) The deblossoming effect was studied on about 200 of the plants set out on September 2nd, the deblossoming operation being performed in May.

(*b*) Following the general planting on September 2nd, a batch of 100 runners of the variety Sir Joseph Paxton was planted on October 20th, 1924, and a similar number of Royal Sovereign runners was planted on April 7th, 1925. These plants were used in studying the effect of the time of planting, and were compared with the normal Series I.

(*c*) It had already been noted that plants with the crowns in poor contact with the soil were generally weak and unhealthy in appearance. It seemed, therefore, that the depth of planting might materially affect the development of the plant. To test this point batches of fifty runners were planted in September, 1924, as follows :—

(i) Normal depth, *i.e.*, with the soil up to the level of the leaf bases so that approximately half the rhizome was below ground.

(ii) Deep planting where only the leaves were above ground level.

(iii) Shallow planting, so that the soil barely covered the roots, and the major portion of the rhizome was above soil level.

(iv) Approximately one-half of the runner roots was removed, transversely from a fourth batch and the root trimmed plants set out at normal depth.

(*d*) In cultivation of the experimental plots normal clean culture was followed as far as possible, but the effects of hoeing the soil away from the plants and, alternatively, of slight earthing up during hoeing have been observed on about fifty plants.

3. (*a*) Examinations of abnormal plants have been carried out as occasion demanded during the season, the plants under consideration being carefully lifted and washed in the manner previously described. In addition, observations have been made on many abnormal plants allowed to remain *in situ* during the season, with a view to finding whether any such plants regain a normal condition.

(*b*) In this connection also experiments have been performed to ascertain the effect of damage to the main crown on the future development of the plant.

IV. Results for Season 1924-25.*

1 *The Normal Development of the Strawberry from September 2nd, 1924, to September 16th, 1925.*

The effect of transplanting from the runner bed to the permanent quarters was to cause the death of the lateral roots and of the tips of the main runner roots. Very active root growth commenced soon after planting and continued until about the middle of December. The shoot growth was by no means proportional to the root growth made in this period.

A certain amount of root death was observed in December, but was ascribed to seasonal conditions and was not deemed to be of normal occurrence. There was a dormant period which lasted from the middle of December until the beginning of March, when growth of both root and shoot recommenced. In this second phase of growth, which continued until the cropping season was ended, there was a large shoot growth, new leaves expanding, and the flowers developing and the fruit maturing. The root growth was small, consisting mainly in the production of "feeding" roots on the scaffold roots already present, although a few new primary roots were formed. What might be called the third phase of growth commenced after the cropping season, and was still in progress in mid-September. This phase represents vigorous growth of both root and shoot. New crowns were formed, resulting in great increase in the bulk of the plants. Root growth commenced at the end of June, and was at first slow, but became very vigorous by the beginning of August. This root growth consisted in the production of new primary roots and of new lateral roots all over the old root system. These new primary roots had their origin mainly at the bases of the new crowns, and above the point of origin of the older roots. (See Plate II., figs. 1 and 4.)

* The results obtained in the "normal" series (1), the deblossomed series (2) (*a*), and the Spring planted series (2) (*b*) (i), are briefly recapitulated here in order that the results of special treatments described later may be readily compared and their significance appreciated.

A full account of this portion of the work will be found in the Journal of Pomology and Horti. Sci. Vol. V., No. 3, 1926.

2. *The effect of special treatments on the development of the plant.*

(*a*) *Deblossoming.*

The effect of not allowing plants to mature a crop of fruit was to increase the vigour of the plant. The deepening in colour of the older roots was delayed. The difference in vigour of root and shoot between the cropped and deblossomed plants, easily observable four weeks after the removal of the flowers, became most marked by July 20th, but was not so noticeable by August 10th. The difference in vigour of the plants subjected to the two treatments was still appreciable in mid-September, greater difference being exhibited by the roots than by the aerial portions of the plants.

(*b*) *Time of planting.*

(i) Spring Planting.—The root growth made up to mid-summer by the runners planted in the Spring consisted mainly of the growth of new feeding roots, although a few new " primary " roots were formed. The commencement of a new phase of root growth was observable by July 20th, when new main roots could be seen which had their origin distinctly above that of the older ones. A considerable growth of both root and shoot had taken place by August 10th. By mid-September as much as half the total bulk of roots consisted of those formed since mid-summer, a proportion greater than that observed for the autumn planted runners. At this date the difference in vigour between the plants set in Autumn and Spring respectively was much less than it had been hitherto, some of the Spring plants being as large as those planted in the Autumn.

(ii) October Planting.—Runners of the variety Sir Joseph Paxton were planted on October 20th, and Plate I fig. 2, which was taken on Jan. 12th, 1925, gives the comparison between a plant set on October 20th with one planted on September 2nd. The great difference in vigour in favour of the September plant is very clear. In Plate I, fig. 3, the condition of a September plant on May 11th, 1925, is compared with that of an October plant and another planted in the Spring. It will be seen that late Autumn planting was in no way more advantageous than Spring-planting, and that both resulted by the following Summer in plants decidedly less vigorous than those planted in the early Autumn.

(*c*) *Methods of Planting.*

(i) *Deep planted.*

October 16th, 1924. The new main roots were rather fewer in number, but just as many lateral roots were being produced on the original runner roots as in the normal plants. The amount of dead roots was noticeable, but on the whole the root system was not

PLATE I.

Illustrating the effect of :—(*a*) Different methods of planting Strawberry Runners, (*b*) Time of planting runners.

FIG. 1. Normal. Shallow planted. Roots trimmed.
Planted September 2nd, 1924. Condition on October 13th, 1924.

FIG. 2. Planted—September 2nd, October 20th.
Condition on January 11th, 1925.

FIG. 3. Planted—Sept. 2nd, 1924. Oct. 20th, 1924. April 7th, 1925.
Condition on May 11th, 1925.

PLATE II.

METHODS OF PLANTING.

FIG. 1. Normal.

FIG. 2. Deep planted.

FIG. 3. Shallow planted.

FIG. 4. Roots trimmed.

All the above plants planted September 2nd, 1924.
Condition on September 16th, 1925.

much inferior to that of plants which had been planted at the normal depth.

November 19*th*, 1924. The observations were of a similar nature to, and confirmed those made on October 16th.

September 16*th*, 1925 (Plate II. fig. 2). Neither root system nor shoot was inferior to that of the normal plants. The rhizome or underground portion was very long, and consequently the point of origin of the new roots appeared to be about two inches above the old ones, as compared with one inch on the normal plants. This point is illustrated by Plate II., fig. 2. It must be stated that the plant illustrated was not absolutely typical of all deeply planted plants : it was selected as it showed well the increased length of the crown, and a portion of the root system was removed before photographing. An average plant would have had a better root system but just as long a crown.

(ii) *Shallow Planted.*

October 16*th*, 1924 (Plate I., fig. 1). The original runner roots were noticeably well furnished with laterals ; in fact they compared favourably with the normal plants in this respect. The new primary roots were fewer in number than on the normal plants, and had their origin at the same nodes as the older roots and not higher up. Many of these new primary roots had not developed normally, their growth having been arrested before they reached the moist environment of the soil. The effect of shallow planting would probably have been greater in a drier season, but the result was not very serious at this date on the plants examined.

November 19*th*, 1924. New primary roots which had developed were only at the same stage as were those of the normal plants on October 16th, in that they were as yet not well furnished with laterals. It was noticed that the exposed portion of the new primary roots was coloured with a red pigment.

September 16*th*, 1925 (Plate II., fig. 3). As a result of cultivation the position of the main crown in relation to the soil was not well maintained, and consequently the difference in vigour between the shallow planted and normal plants was not great at this date. But on the whole the root system was not so vigorous as that of a plant set at the normal depth. When it happened that the new roots had their origin at some distance from the soil level (this frequently occurred on one side of the plant only), it was noticed that they were red in colour and that the tips had died.

(iii) *Roots Trimmed.*

October 16*th*, 1924. Lateral roots were abundantly produced near the region of the cut ends of the runner roots. This is well illus-

trated in Plate I., Fig. 1. The new primary roots seemed to be more abundant than on the normal plants, and to have their origin mostly above the old roots. In addition, they were stronger and better furnished with laterals, and in some cases were longer than the old primary roots of a normal plant, the length of the longest being 16 cm. The bulk of the root system of one of these plants was equal to, if not greater than, that of a normal plant whose crown was of the same size—hence the volume of new roots was greater, the increase being both in laterals on the cut runner roots and in new primaries with their laterals.

November 19*th*. Root growth was still obvious.

September 16*th*, 1925. At this date the plants were in no way superior in vigour to those the roots of which had not been trimmed. The vigorous roots which had been produced at the cut ends of the runner roots were still well furnished with living laterals. The difference in appearance of the root system from that of a normal plant is well seen by comparing Plate II., fig. 4, with Plate II., fig. 1, the former being, as it were, hollow in the centre.

3. *The Examination of the Root Systems of Various Forms of Abnormal Plants.*

a. The root systems of abnormal or unhealthy forms of plants, growing both in pots and in the field, were examined in order to ascertain whether the abnormality was due to a defective root system.

In the Field. In early August were examined several plants of an unhealthy appearance, *i.e.*, those with small deformed young leaves or of poor vigour generally. The conclusion drawn was that the poor condition of the shoot portion was not due to the death of, or damage to, an appreciable proportion of the roots. As a rule the root system was healthy, but always proportional in amount to the aerial portion of the plant, hence the condition of the plants was not due to death of the roots, but to some factor either preventing new root formation, or preventing the development of an efficient leaf area. The condition of the plants whose crowns were not in good enough contact with the soil was probably due to the former factor.

Potted Plants Growing in Soil. Early in August some plants were selected which had small deformed and yellowish leaves with short petioles, and at the same time a similar number of healthy plants were chosen. These were turned out of their pots and the root systems examined. In both cases the majority of the roots were found to seek the edge of pot and the neighbourhood of the crocks at the bottom. The root systems of the pot plants were

PLATE III.

EFFECT OF CROWN DAMAGE.

FIG. 1. Main crown cut off.
Condition of plants in the Spring.

FIG. 2. Later stage of fig. 1 above.

1. 2. 3. 4.

FIG. 3. 1, Normal leaf.
2, 3 & 4, Leaves from damaged plant.

distinct from those of plants grown in the field in that the length of the main roots was much greater and the amount of fibrous root much larger.

The healthy plants showed production of new primary roots and little root death, whereas the others showed rather more root death and no new growth of primary roots. This might well be the result of either a defective root system or defective shoot growth. The writers incline to the view that it was due to the latter cause, after considering the evidence afforded by the plants growing in the field.

b. The Effect of Damage to the "Crowns."

In the course of making observations on Strawberry plants, it was noticed in the Spring that certain plants occurred which had a distinctive type of abnormal foliage (Plate III., fig. 1). The leaves were smaller than usual, of a thinner texture than normal leaves, and the petiole was longer and thinner in proportion to the leaflets than was usually the case. In addition the leaf blades were abnormal in shape, and the serrations were fewer than usual. Some of these plants were carefully dug up and examined, and it was found that the main crown had been severed and that several weak buds below the cut had developed, giving weak lateral crowns with the type of foliage described above. This condition seems to be analogous with "temporary reversion" in the black currant. The latter condition is produced by cutting a bush back hard and causing weak buds to break. These produce shoots bearing an abnormal type of leaf, very similar to the "reverted" leaf. The condition of the Strawberry plants above described was in all probability due to hoe damage, in which the top of the crown had been completely severed. In order to confirm this view the crowns of a number of plants were cut at ground level. A condition identical with that described above was produced, as shown on Plate III., fig. 3. Observations were made on those plants throughout the season, and it was noticed that eventually a very dense form of plant was produced, having leaves of the normal shape and size (Plate III., fig. 2). This was due to the growth of a relatively large number of crowns very close to one another.

V. Discussion.

Methods of Planting.

The effect of deep planting was to cause a certain amount of root death, but the ultimate vigour of the plants was not much impaired. The increase in length of the main crown as compared with that of plants set at the normal depth was noticeable. The effect of shallow planting was more detrimental, resulting in the death of some of the new primary roots, which were unable to reach the moist soil

before succumbing to drought. The trimming of the runner roots before planting did not impair or enhance the ultimate vigour of the plants. The treatment resulted in the copious production of lateral roots near the cut ends of the main runner roots, and six weeks after planting the bulk of the roots was the same as that of a normal plant, hence the growth of new roots had been greater.

Observations on Abnormality.

A number of abnormal plants growing both in pots and in the field were examined to ascertain whether the abnormal (defective) shoot growth was due to death of, or damage to, a portion of the root system. The conclusion drawn was that damage to the root system was not responsible for the condition of the plant, except in cases where the crowns were badly exposed, leading to the desiccation of the young roots. On the plants examined the root systems were usually healthy, but always in proportion to the aerial portion of the plant.

VI. Possible Practical Application of the Results obtained.

The observations which have been made on the season of root growth and on the point of origin of the new main roots would seem to indicate at least the time of the year at which root growth might be assisted, or at any rate not hindered. The most vigorous growth of new roots has been seen to have commenced by the beginning of August, that is to say, by about one month after cropping. This points to the value of cleaning the strawberry rows as soon as possible after cropping, in order not to cause disturbance of the new root growth. Severe exposure of the crown should at all times be avoided, since it is bound to be prejudicial to root growth, the new roots having been seen to have their origin markedly above that of the older ones. Conversely, it seems likely that root growth might be assisted by a slight moulding up of the plants after cropping—however, no recommendations will be made on this point until it has been tested out in the field. Observations made in the field confirm this view of the value of close proximity between soil and crown, plants with exposed crowns being poor in vigour and often having undersized leaves. This has long been recognised, but is often forgotten. In 1881 Thompson* writing on strawberry cultivation in "The Gardener's Assistant," states that "If the stem of any strong growing sort be taken and the lower leaves stripped off, it will be seen that there are a number of white points ready to push, if circumstances should be favourable for their doing

* Thompson, Robert. "The Gardener's Assistant." London. Blackie and Son, 1881.

so. They do not push through the coatings formed by the bases of the leaves above ground, but if the stem is buried in soil, or in a good top-dressing of rotten dung, leaf mould, or even leaves, they will strike root, in consequence of which the plants will be greatly invigorated . . . ." Our own observations fully confirm this.

A NOTE ON STRAWBERRY "STRAINS."

By E. Ball.

One of the points usually insisted on in books or articles on Strawberry growing is that the grower should first of all obtain runners of a good "stock" or "strain" of plants. By this is usually meant a stock of plants which is vigorous, crops well and is true to name. The question which naturally arises is: What is meant fundamentally by the word "strain" when applied to such a plant as the Strawberry which is always propagated by asexual methods, except in the raising of new varieties? (Alpine varieties are not being considered in this article). It is quite a different matter when the term is applied to a number of poultry or peas, which are always increased by sexual methods. Here, division and mingling of the chromosomes of two parents takes place, and there is the opportunity for some rearrangement of inherited characters. Johannsen demonstrated the existence of "pure lines" in beans, and that it was not possible to pass from one "pure line" to another by mere selection, but that the weight of the seeds could be increased by selection, if a number of "pure lines" were present, by the gradual elimination of the lower yielding "pure lines." However, when dealing with the Strawberry there can be no possibility of a collection of "pure lines," the wider meaning of the phrase suggested by Morgan* being used here, unless the occurrence of "bud-sporting" is admitted. In this case it is necessary to assume that in the production of runners from the parent plant, some slight change in the arrangement of the genes, or, as it were, compartments of the chromosomes sometimes takes place—making no difference in the outward appearance of the plant, except perhaps in its vigour, but resulting in a very different yield of fruit. If this is not the true explanation of the difference in yield obtained from various "strains" of Strawberry grown under the same conditions of cultivation, etc., there are at least three other possible explanations. First, it may be simply a question of the vigour of the runner which is put into the ground, *e.g.*, the big runner producing the big plant, in virtue of its better start in life. Secondly, it may be a question of health, the lower yielding "strains" having a higher proportion of plants infected with some disease. A third cause of the difference in yield might be the

* The Physical basis of Heredity. T. H. Morgan, 1919.

admixture of " rogues " with the true stock, which would result in a smaller crop owing to their smaller cropping capacity, or complete " blindness " or absence of blossom. In order to find out which of these factors is responsible for the difference in yield of various " strains," and to what extent, a number of experiments have been started at Long Ashton. Some results have already been obtained, but the complete story is not yet unfolded, and hence this article only purports to be a progress report.

In 1923 two experiments were started by Mr. G. S. Peren at this Station. In the first a number of " strains " (six) of the variety " Royal Sovereign " were obtained from the Cheddar Valley District, and planted side by side at Long Ashton, with the intention of taking crop weights from them over a number of generations. The Cheddar Valley Strawberry growing district is small in area, but the soil variation is considerable and, as elsewhere, all the growers do not give the plants identical treatment. Thus, it should be possible, from this material to ascertain whether after a number of generations, these strains which were once growing under different conditions and receiving different treatment, would eventually yield even crops when grown side by side under exactly the same conditions. Should this be the case, difference between one " strain " and another in this instance is merely a question of environment and size of the runner. By environment is meant the climate, soil conditions, and the treatment given to the plants. Two crop weights have been obtained from the first generation of plants, which were allowed to crop in their first season, since they were planted in early September. From these figures a base line is obtained, *i.e.*, the variation in yield of the different strains at the commencement of the experiment is known. These figures show that the best strain crops just about half as heavily again as does the poorest. The difference in vigour of the plants as seen in the field is very marked, those of one strain being at least half as large again as those of another. In September, 1924, a second generation of plants was planted out and the first crop weights were obtained from these this year, and showed considerable variation. A third generation has been planted in August of this year (1925).

The second experiment was designed to determine the effect of the selection of parent and of runner on the yield obtained. In the first stage selection of runner only was considered, as follows :—

(1) best runners.
(2) all runners.
(3) poorest runners

} from parents layered to three plants each.

(4) All runners from parents allowed to make unlimited runners.

Thus runners were selected (*a*) by grading and (*b*) by restricting the number made by the parent plant.

From these plants crop weights from two year old plants are available. The difference between the weights obtained from 1, 2 and 3 are small and well within the limits of experimental error, but the weight obtained from 4 is very much below that from the three other stocks, the ratio being 1 : 3. The difference in the vigour of the plants 1, 2 and 3, as compared with 4, is very marked, and it is interesting to note that the smaller plants of 4 cropped earlier than did those of 1, 2 and 3, the first two pickings being markedly heavier from 4 (more than twice as heavy). This is almost certainly due to the more dense foliage of the larger plants retarding the ripening of the "berries." The lack of difference in cropping between 1, 2 and 3 is probably due to the severe restriction of the runners, which were limited to three, thus producing a vigorous stock not exhibiting very great range in size. In a further stage of this experiment, for which runners were planted in September, 1924, another factor was introduced, viz., the selection of parent. However, it is not advisable to draw any conclusions from the result of this operation until the crop weights have been obtained from two year old plants.

In addition to the experiments just described further work is in hand on the subject of strawberry "strains." A second selection experiment will be commenced this coming season designed to estimate the effect of the following factors on the ultimate yield obtained :—

(1) Selection of parent.
(2) Selection of runner—
    (*a*) by limitation of the number formed.
    (*b*) by eliminating a certain percentage at the time of raising from the runner bed.

In this case the factors, (1) selection of parent and (2) selection of runner, will be kept quite separate. The original parents were planted in September, 1925.

Close observations have been made in the field on a number of plants of the varieties "Royal Sovereign" and "Stirling Castle," and plants exhibiting certain characters have been isolated and the runners from each kept separate, *i.e.* "clones" have been formed and in effect constitute a number of pedigree Strawberry plants, since the history of the parent of each is known. The parents have been selected as exhibiting the following characters :—

(1) Differences in vigour and habit.
(2) "Blindness" or absence of blossom.
(3) Difference in proportion of blossom to foliage.
(4) Abnormal types of foliage.

In addition, the vigour of each runner was noted at the time of planting. From this work it should be possible to ascertain to what extent any of these characters are inherited.

At the commencement of this paper four possible causes were suggested as the explanation of the different cropping powers of various " strains " of Strawberries.

(A) The existence of " pure lines."
(B) Simple differences in vigour due to environment.
(C) Health of the plants.
(D) The presence of a large proportion of " Rogues."

Any or all of these causes might operate at once in producing a poor strain.

If (A) is one of the causes, the selection of parents should bring about an increased yield, since it would be possible to increase the proportion of the heavier cropping " pure lines."

If (B), restriction of the number of runners and better treatment of the plants should rapidly raise the yield.

If (C), the strain would probably be improved by eliminating all abnormal or diseased parents from the runner bed. There is evidence that, at any rate, some abnormal types of foliage may be inherited in the runner.

If (D), careful rogueing should raise the yield. This factor often operates to lower the yield of Strawberry fields. This is especially so with the variety " Stirling Castle " in some fields of which a large percentage of " rogues " can be seen. They are sometimes " blind " or totally devoid of blossom, and produce runners in immense numbers, and consequently soon spread over the field, or, if present in the runner bed, rapidly lead to the deterioration of the " strain." These plants are easily recognised, since the foliage is quite distinct from that of the true " Stirling Castle, " the leaflets being of a bluish green colour and incurved, and if any flowers are present they are much larger, and consequently more conspicuous than are those of the " Stirling Castle." " Rogues " are also found among other varieties, *e.g.*, " Sir Joseph Paxton." This cause of poor yields is, however, easily remedied, at any rate in the case of " Stirling Castle," by careful rogueing of the runner beds.

In conclusion, the following points of practical application which arise out of this brief discussion may be stressed :—

(1) The value of obtaining runners of good quality when buying.
(2) When propagating eliminate all " rogues " and diseased plants from the runner bed.

(3) Some restriction of the number of runners allowed is worth consideration, especially in cases where a crop is to be taken in the first season after planting.

(4) There is not yet sufficient evidence to indicate whether great advantages would accrue from the selection of parents in the runner bed, other than by the elimination of diseased plants and plants not true to name.

(5) Finally it follows that runners should only be obtained from a special bed of maiden plants which can be carefully selected and rogued for diseased plants, or plants not true to name.

SOME OBSERVATIONS ON STRAWBERRY EELWORM.

By L. N. Staniland.

A progress report on " Red Plant " of strawberries was rendered in the Annual Report of the Station for 1924. It was stated in that report that infection experiments with *Aphelenchus* were to be carried out. These experiments, as originally planned, were not proceeded with, since it was found that a large percentage of the material was already naturally infected with *Aphelenchus*. The plants had been selected with the greatest care, no plant with the slightest suggestion of the presence of any " red plant " or " cauliflower " symptoms being used. The circumstances therefore suggested the view that *Aphelenchus* is a frequent inhabitant of the normal strawberry plant. The plants examined all also contained eelworms of the genera *Rhabditis*, *Cephalobus* and *Dorylaimus*. It was clear therefore that means of freeing the plants from eelworm were required before decisive results from infection experiments could be expected, and extensive experiments with that object in view have been made. This work is not sufficiently complete to place on record at the present stage and in the meantime it was considered desirable to carry out a small preliminary infection experiment, the details of which are recorded below, since they may be of service to other workers.

a. Technique for the Infection of Plants with Eelworm.

It may be of interest to give some account of the methods whereby sufficient numbers of *Aphelenchus* were obtained for purposes of infection. Sufficient numbers could be obtained for a few infections by the simple process of washing leaf-bases, or portions of a plant badly " cauliflowered," with water into a watch-glass and indeed this method was used in the cases of the infections which were actually made. The following method has been evolved in readiness for infection work on a larger scale. The method consists of the use of a simple piece of apparatus, sometimes combined with the use of a centrifuge. The apparatus, a diagram of which is given (Fig. 1), may be described as follows.

A large glass boiling tube (A), about $1\frac{1}{2}$ inches in diameter, is fitted with a rubber cork (B) with three holes bored through it. Through the central hole passes a long, parallel sided funnel (C), the stem of which is sufficiently long to pass almost to the bottom of the tube. Through one of the other holes passes a short glass tube (E) to which is attached a small hand-bellows such as is used on an atomiser. The third hole has another short glass tube (D) drawn out so that the hole at the end outside the tube is quite fine. At the base of the funnel is placed a disc of perforated zinc the diameter of which is a little less than that of the funnel (G). To this disc is soldered a length of wire. The purpose of this arrangement is to prevent the material from which the eelworms are being obtained from clogging the hole at the base of the funnel, or from passing down into the water (W) which is at the bottom of the large tube. It also facilitates the removal of the material from the funnel.

The apparatus is used as follows. The material, from which it is desired to obtain the eelworms, is placed in the funnel. A little water is poured into the tube through the funnel. On gently working the bellows the water in the tube is forced up into the funnel. When all the water is in the funnel, continued blowing causes air to bubble through the water and the material, and in this way washes out most of the eelworms. When blowing ceases, the liquid falls back into the tube. The funnel should be sufficiently high to prevent water being blown out and the hole in the end of the tube (D) should be of such a size as to allow the water to run down fairly quickly out of the funnel into the tube when blowing ceases, and also to permit it being raised to the funnel by gentle blowing when required. The amount of water in the tube and the material in the funnel should be so adjusted that the water covers the material when it has all been forced up into the funnel. The process is repeated two or three times, and then the material is changed ; but the same water is used again. The concentration of eelworms, therefore, increases in the water. Where the material has eelworms present in fair numbers, no centrifuging is necessary, but where this is not so, centrifuging will give a greater concentration. By stirring the water containing the eelworms, taking out one or two drops, and counting the eelworms present, it is possible to infect with an approximately known number of eelworms. No method has been found of separating Aphelenchus from the other genera, but the percentage of Aphelenchus can be calculated.

b. Description of the Infection Experiment.

Twenty four plants of the variety Royal Sovereign were each infected with about ten *Aphelenchus*, along with the other

eelworms of the strawberry plant obtained in the eelworm extract. The eelworms were put into the outer leaf bases of each plant during September, 1924. During December, 1924, similar infections were made in the growing points of eight plants of the same variety. The number of eelworms was about the same, and ten of them, in each case, were *Aphelenchus*. The worms were introduced by means of a blunt-ended pipette to a point as near the growing point as possible. The remainder of the plants, (over 200), were under the same conditions and formed an ample control. So far (January, 1926) none of the infected or control plants have developed any definite symptoms of "red plant" or "cauliflower" disease.

c. Breeding of Aphelenchus Under Artificial Conditions.

Though it was found that the eelworms *Rhabditis* and *Cephalobus* could be bred in strawberry leaf-extract agar and in other ways, no success was obtained in the case of *Aphelenchus*. This would suggest that *Aphelenchus* is not free-living in its habits.

d. The Presence of Aphelenchus in the Soil.

The possible presence of *Aphelenchus* in the soil being of importance in connection with strawberry pathology, various attempts have been made to separate these organisms from soil, but none succeeded until the following method was tried. The writer is indebted to Dr. T. Goodey, of the London School of Topical Medicine, for the suggestion that a flotation method might be successful.

Solutions of common salt and calcium chloride were used, the former giving the best results. The soil samples tested consisted of a number of small amounts taken in the region of plants affected by "red plant" disease. The top $\frac{1}{2}$-inch of soil was taken and a number of samples mixed together. The combined sample was worked through in the following manner. About three grams of soil was placed in each of a number of small test tubes and about 5 cubic centimetres of a cold saturated solution of salt added. The tubes were thoroughly shaken and allowed to stand for about five minutes. The eelworms floated to the top and the soil sank to the bottom. The eelworms could be pipetted off and examined. Although a certain amount of plasmolysis of the tissues of the eelworms took place, it was found possible to separate them readily into two classes, i.e., Aphelenchus and other genera. The results from three plots infected with "red plant" were as follows :—

Plot No.	*Size of Soil sample.*	*Date taken.*	*No. of Eelworms*	
			Aphelenchus	*Other genera.*
1.	About 8 cubic inches,	Jan. 29th/25.	2	18
2.	About 3 cubic inches.	Jan. 29th/25.	0	14
3.	About 9 cubic inches.	Feb. 4th/25.	2	46

The figure representing the number of *Aphelenchus* as a percentage of the total number of eelworms recovered from all the samples is just under 5. This figure of 5% might easily be explained by the washing out of eelworms from the plants by rain as discussed in the progress report last year. It would, therefore, seem that it is doubtful if *Aphelenchus* is present in the soil except in an accidental way.

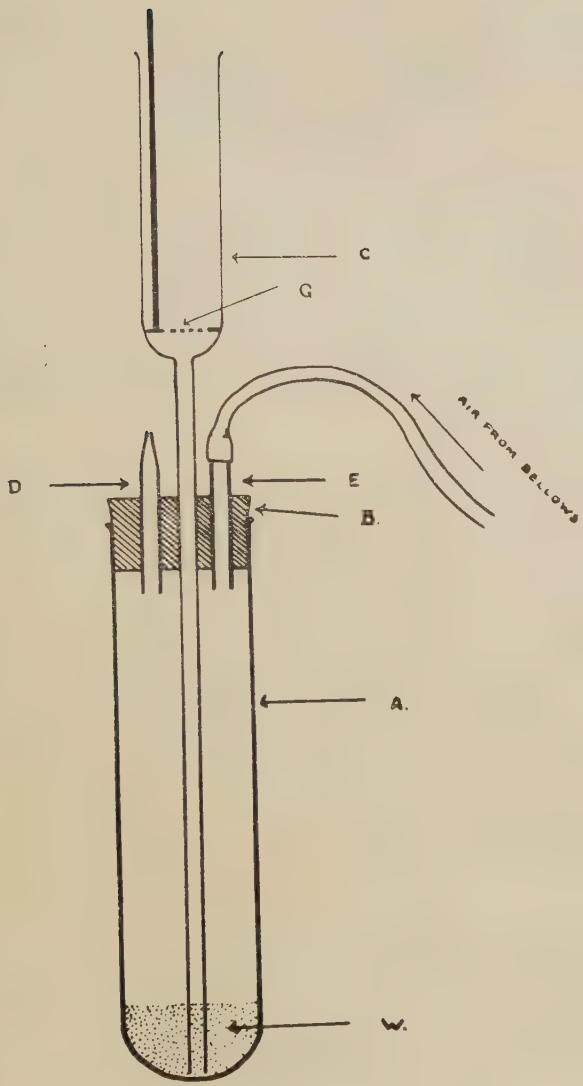

Fig. I.

Diagram of Apparatus for obtaining a large number of Eelworms in a small volume of water.

REVERSION DISEASE OF BLACK CURRANTS: MEANS OF INFECTION.*

By A. H. Lees, M.A.

The following paper deals mainly with work that has been in progress for some years, but which, from its nature, did not admit of a speedy culmination. Statistical observations have been continued this year with the assistance of Mr. C. E. T. Mann, Plant Physiologist at Long Ashton, who is responsible for the presentation of the evidence relating to them. The investigation of the disease has long called for the co-operation of a competent physiologist as there are many promising lines which can only be fully explored by modern methods.

In previous papers dealing with Reversion in Black Currants attention has been directed to such points as the characters of the disease(1), means of identification(2), possible connection with the Black currant mite, *E. ribis*(3), and control. At the same time, however, various experiments were started with a view to elucidate its means of entry into the plant. The most obvious line was to investigate by direct experiment the influence of an infection of mite on healthy plants. Cases of disease, however, were comparatively frequent where no possible connection could be traced between mite and the infection of reversion. Thus it was by no means infrequent to find new cases of reversion arising in which either no mite could be found or mite was present in such small quantity as to suggest that it was not the true cause.

Grafting Experiments.

Accordingly, in order to test whether the disease could be propagated, trials of grafting were started in the year 1920, and were continued in 1921. These first two years, for various reasons, gave only failures. It was not then easy, nor has it proved easy subsequently, to obtain grafts on the black currants. The graft can be made but a successful union is not often obtained. On the only successful grafts of 1920 a tree was felled so that even where there was a chance of obtaining a positive result this chance was ruled out by accident. This sort of experience was repeated

* Reprinted with the permission of the Editors, from the Annals of Applied Biology, Vol. XII, No. 2, May, 1925.

in a similar manner for grafts on plantation bushes where in most cases, before results could be obtained, the graft was knocked off or out by cultivating tools or the whole situation was complicated by the arrival of big bud.

Owing to these various reasons it was decided to make grafts very largely on pot trees so that the plants could be preserved free from accident and if possible from mite infection, until either positive or negative results could be recorded.

Table I sets out the results obtained from grafting reverted scions on healthy stocks.

TABLE I.

Effect of grafting diseased scions on healthy stocks.

No.	When grafted	With what	Same year plant	2nd year		B.B.	3rd year	
				Flowers	Shoots	Present	Flowers	Shoots
1	Spring 1922	Revert Boskoop 2. 1. 13	N	N	N	No	N	N except shoot near base
2	,,	Do. 2. 3. 21	,,	,,	,,	,,	R	R
3	,,	,,	,,	,,	,,	Yes on graft	,,	,,
4	,,	Do. 2. 1. 13	,,	,,	,,	No.	Part R ,, N	R except shoot near base
33	,,	Revert Seabrook 6. 1. 13	,,	,,	,,	,,	None	One shoot Rev. 6
36	,,	,,	,,	,,	,,	,,	,,	Some leaves Rev. 4
34	,,	,,	,,	,,	,,	—	—	—
35	,,	,,	,,	,,	,,	—	—	—
14	Spring 1923	Revert Boskoop 2. 5. 6	Some temporary reversion	,,	R	No	—	—
15	,,	,,	,,	,,	R and N	,,	—	—
16	,,	,,	,,	,,	,,	,,	—	—
17	,,	,,	,,	,,	N	,,	—	—
18	,,	,,	,,	,,	R and N	,,	—	—
19	,,	,,	,,	,,	R	,,	—	—
20	,,	,,	,,	,,	R and N	,,	—	—
21	,,	,,	,,	,,	,,	,,	—	—

In every case the stock plants were kept under observation for one or two years previously in order to rule out, as far as possible, all chance infection.

The 1922 grafts were made with grafts from three different sources, two being Boskoop Giant and one Seabrook's Black. In each case the stock used was the same variety as the scion. Of the eight 1922 grafts, six ultimately produced reversion on the stock by 1924, while two were still free in 1923, but were lost during the operation of repotting. The original bush Seabrook 6. 1. 13 was only slightly affected at the time that the grafts were cut, and this weakness reappears in the stock to which the disease has been communicated. In the two successful cases, though reversion showed on a shoot in each case, the intensity, judged by the leaf-vein method, was slight (veins 6 and 4).

Disease on Boskoop 2. 1. 13 and 2. 3. 21 was apparently of equal intensity when the selection of grafts was made, but their subsequent history suggests that the disease 2. 3. 21 was stronger. In this case by 1924 the shoots and flowers from the stock were fully revert with the exception of one basal shoot in one of the two plants.

The 2. 1. 13 grafted stocks in 1924 still showed a fair proportion of normal shoots and flowers, though the disease had quite evidently appeared on some. In only one of these eight 1922 grafts did Big Bud appear and this was on a graft and not on the stock.

The 1923 grafts were all Boskoop on Boskoop and the bush selected for grafts was of a pronounced revert type. In the summer of 1923 all the eight grafted stocks showed well-marked temporary reversion due to the cutting back that was done after grafting. There is nothing to suggest that the disease made a quick infection from graft to stock during the year of grafting, and the results for 1924 show that even then the disease was not spread throughout the stock. In no case were any of the flowers on the stock shoot revert. The leaves, however, showed the beginning of the spread of the disease. In number 17 no infection had been made. In 15, 16, 18, 20 and 21 some shoots were revert and some normal. In 14 and 19 the shoots were all revert. The intermediate cases, where both normal and revert shoots were produced from the stock, were particularly interesting, as in them the course of the disease could be distinctly traced. Fig. 1 illustrates the result obtained for number 15. The shoot behind the graft, which did not " take," is clearly reverted, while the shoot issuing a little further away was still healthy when the photograph was taken. This slow progression of the disease is also shown in Figs. 2 and 3, but especially in 2, where the shoot immediately behind the graft was most reverted, the next one less so, and the one farther away quite free. In all these 1923 cases the graft failed to " take," but this fact did not prevent the propagation of the disease though it may have lowered its rate of spread.

These sixteen grafted plants would appear, therefore, to suggest the following conclusions :

(1) That reversion can be propagated by contact.

(2) That it is therefore an organic and not a functional disease.

(3) That since no organism has been found after many attempts the disease probably belongs to the class of virus diseases.

(4) That it is propagated slowly from the point of infection downwards, thereby infecting shoots arising lower than the point of infection.

(5) That the rate of propagation and the intensity of the attack depends directly on the intensity of the original infection.

(6) That its propagation *can* be quite independent of the presence of Black Currant Mite.

Statistical Observations.

The season 1924 has been remarkable for the large increase in the number of fresh cases of reversion. Statistical investigation of the disease, continued on a plantation of 547 bushes comprised of Hatton's four main groups, showed a percentage increase of approximately 7 per cent. in Baldwin (Strain I), 9 per cent. in Edina, 11 per cent. in Seabrook's Black, 13 per cent. in Boskoop Giant and 23 per cent. in Baldwin (Strain II). The results of the investigation are summarised in Table II and the percentages quoted above are calculated on the number of healthy bushes remaining in the various groups at the time of the last marking, namely the foliage marking in 1923.

As stated in a previous paper(5), up to 1923 the number of new cases of the disease was steadily decreasing and only four fresh cases, less than 1 per cent., were observed in that year.

Table II.

Variety.	Number of bushes 1920	Reverts. 1921	1922	1923	1924	Increase in number of Reverts. 1922	1923	1924	Remaining healthy 1923	Percentage increase 1924
Edina	115	28	26	25	33	3	1	8	90	8.9
Boskoop Giant	123	5	6	7	22	1	1	15	116	13.0
Seabrook's Black	134	6	8	10	24	2	2	14	124	11.2
Baldwin I	57	0	0	1	5	0	1	4	56	7.1
Baldwin II	118	4	7	7	32	3	0	25	111	22.5
Totals	547	38	47	50	116	9	3	66	497	13.27

The bushes were carefully marked in April and early May, according to variety, for the presence of the typical "revert inflorescence" and in June for signs of the disease exhibited by the terminal foliage(2). A total of 77 fresh infections resulted from the two markings, the total number of affected bushes being 66. The difference between these two figures may be accounted for by the fact that it is quite possible to find two twigs or branches on the same bush remotely connected through the stool and showing the presence of the disease in differing intensity and at different periods of the season, a condition which indicates separate infections.

Considering the flower markings made in April and May, of a total of 25 twigs and branches bearing revert inflorescences, 19

produced revert terminal foliage later in the season. Infection varied from a single truss in slight cases to all the trusses on a fruiting twig. The extent of the variation is shown in Table III.

TABLE III.

Summary of new infections.

	Presence of reversion established on :—									
	Flower mark only	Flower and Foliage marking.					Foliage marking only			
		Twig				Branch	Twig	Branch	Stool Shoots	
Variety.	One rev. truss N. foliage.	Isolated R. truss Terminal fol. R.	Upper trusses R. Terminal fol. R.	Lower trusses R. Terminal fol. R.	All trusses R. Term. fol. R.	Whole branch R. infs and fol.	Terminal foliage R.	Terminal foliage of main and laterals R.	and laterals arising near pruning cut	Totals.
Edina	1	0	2	1	2	0	0	2	0	8
Boskoop Giant	1	0	2	2	1	2	6	4	1	19
Seabrook's Black	0	0	0	0	1	1	10	1	3	16
Baldwin I	1	0	0	2	0	0	0	1	0	4
Baldwin II	3	1	0	1	0	1	11	6	7	30
Totals	6	1	4	6	4	4	27	14	11	77

Where only a single truss appeared to be infected, reversion in six cases did not appear later in the foliage. It will also be observed that four of the six cases occur in the Baldwin Group, where recognition of the disease in the inflorescence is much less easy than in the variety such as Boskoop or Seabrook.

The figures obtained on the foliage marking in June illustrate again the possibility of "dosage" or varying severity of infection. Of the total of 52 fresh cases of disease 27 are single twig infections where the terminal foliage in June shows the reduced venation and coarsened margin characteristic of the disease. More severe cases were noted where the terminal foliage on all the current year's growth of a branch was reverted. In addition to the above cases, instances of possible infection through a bad pruning wound were recorded. One case, in Seabrook's Black, showed very clearly the possibility of such an infection taking place. A strong stool shoot of the previous year which had been badly snagged had later in the season produced three strong laterals. Of these, two had arisen near the cut and were strongly revert, while the third, which had its origin at a considerably lower level, was quite normal (Fig. 4). This case seems to form a striking parallel to the case of the grafted plant (Figs. 1 and 2) in which the shoot arising nearest the point of infection by the revert scion has reverted before the shoot of more distant origin.

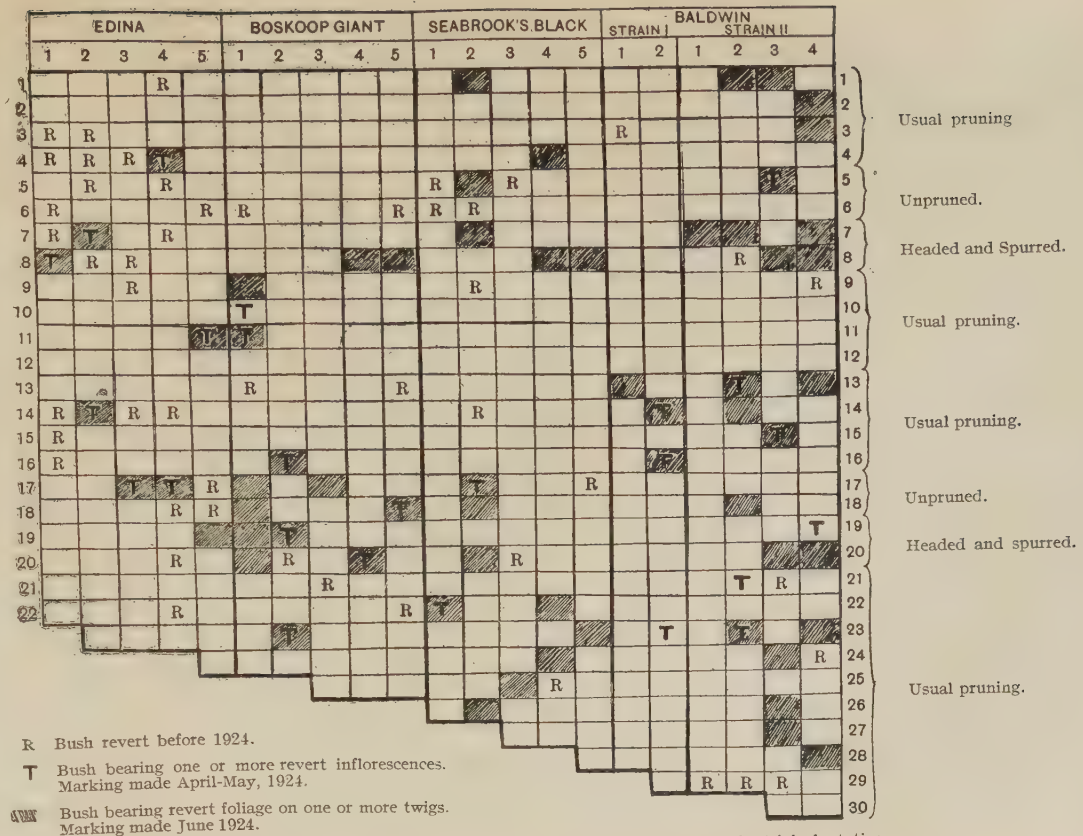

Fig. 1. Chart showing general lay out, treatments and results in the trial plantation.
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The subsequent behaviour of bushes marked for revert inflorescences is worthy of special note. In all cases where one or more trusses had been marked for reversion in April the June observations showed either a complete absence of fruit or the presence of a very few small unripened berries on the infected trusses. On the other hand, the June marking showed numerous cases of fruiting twigs and branches carrying a full crop but showing strongly revert terminal foliage on the current year's growth (Fig.5). It has been suggested that nursery beds may be started free from reversion disease by selecting cutting material only from fruiting bushes. The foregoing observations show that the chance of including revert material is not eliminated by this method and in actual practice usually results in the appearance of about 4 per cent. reverts in the nursery beds.

The relative distribution of previously reverted and newly infected bushes in the plantation is represented in text-fig. 1. An examination of the chart reveals no definite relation between old reverts and new infections; the distribution of the latter seems quite haphazard.

In the chart (text-fig.1) the pruning treatments applied are shown. In addition the first eight rows, including the three pruning methods employed, received a lime sulphur spray of 1 in 12 as soon as the leaves were as large as a sixpence. The next four rows received four sprayings of lime sulphur at 1 in 40 at intervals of ten days. From the thirteenth row the pruning treatments are repeated, but the bushes were not sprayed.

The results summarised in Table IV show firstly that lightly pruned bushes were more liable to reversion than were hard pruned bushes, secondly, that if spraying with lime sulphur had a beneficial effect, especially if the spray was applied at summer strength at four intervals of 10 days, but little benefit accrued from spraying unless the bushes received the usual pruning.

TABLE IV.

Spraying Treatment	Percentage new infections.			
	Rows	Hard pruned	Rows	Light pruned
Lime-sulphur 1 in 12	1-4	9.52	5-8	21.06
,, 1 in 40	9-12	3.22	—	—
Unsprayed	13-16	13.11	17-20	22.95
,,	21-end	13.46	—	—

During the season 1923 the plantation was badly attacked by aphis. From observations made at the time, aphis damage was much less severe on the bushes receiving four sprayings of lime sulphur than on any others. These observations would appear to suggest the possibility of aphis acting as a carrier of the disease, and would explain to some extent the haphazard distribution of

new infections appearing in 1924. This suggestion is supported also by the evidence from grafting experiments, where it is shown that contact with revert material is sufficient for the propagation of the disease in a healthy plant. In the absence of direct evidence the effect of hard pruning in reducing the number of infections can only be surmised, but it may be possible by pruning to remove many mildly attacked shoots before the disease has reached the region where the pruning cut is made.

From the foregoing observations the following main conclusions may be drawn with regard to the new infections of reversion disease for 1924.

(1) Infection with the disease may vary in severity between wide limits.

(2) There is no evidence of occurrence of the disease solely on the ground of proximity of healthy and infected plants.

(3) The possibility of infection by contact with diseased material during the process of pruning is suggested.

(4) There is some evidence in support of the possibility of a pest carrier.

(5) Hard pruning with lime sulphur spraying had a considerable control influence.

To test the evidence obtained from observations in the plantation work has been commenced on the following lines :

I. Injection of the expressed fluid from a revert plant into various parts of a normal plant.

II. Ringing and subsequent introduction into the ringed healthy shoot of the extract from revert shoots.

III. Propagation of green cuttings from a healthy bush previously infected with the fluid obtained from corresponding regions of a revert bush.

IV. Attempted pruning cut infections in the field.

V. Hard wood healthy cuttings treated with extracts obtained from diseased plants.

Possible Carriers of the Disease.

It is clear, that amongst the cases described in the above section there are a large proportion which cannot be explained as infection by contact. Nevertheless, it is obvious that the disease has obtained entry by some means, since those bushes prior to 1924 were healthy.

Undoubtedly the easiest hypothesis to accept is that the disease can be carried by some sucking arthropod from diseased to healthy

bush in the way that is already familiar in several virus diseases (Potato Aphis, *Eutettix tenella* and Curly Top of Sugar Beet, etc.).

At first sight, in view of the frequent close connection of mite with reversion, this arthropod might be expected to convey the infection. This connection is, however, explicable in two ways. Mite may cause or carry reversion or reverted bushes may be more susceptible to mite. That the latter contention is true has been shown by statistical studies already published(4). But this does not preclude the truth of the first contention. The evidence for this is at present conflicting and is derived from two sources, correlations in the field and direct infections. The correlations were derived from two varieties, Edina and Baldwin, now under observation for four years. In the group of Edinas under inspection there are 115 bushes and of these 40 have been recorded as big budded 1 year out of 4, 19 big budded 2 years out of 4, 5 big budded 3 years out of 4, and 1 big budded all four years and yet all have remained free from reversion for all four years referred to. It is therefore clearly possible for mite to be present for any period from one to four years, without the bush becoming revert. A lack of correlation is also shown in the Baldwin Group (Strain II) between mite infections recorded in 1923 and new cases of reversion appearing in 1924. Out of 111 bushes remaining healthy in 1923, as regards reversion, 25 showed the presence of the disease in 1924. On these figures the probability of a bush of this variety reverting in the past season was 25/111 or 22.5 per cent. Of the total of 111 bushes revert in 1923, 28 were found to be mite infected in December of that year, and of these 7 were revert in 1924. The probability of a mite attacked bush becoming revert is 7/28 or 25 per cent. These two figures for probability of infection indicate a very slightly higher probability in the case of mite infected bushes, but the difference between the two figures, namely 2.5 per cent., is much too small to be significant and is well within the limits of experimental error.

The evidence for mite producing or carrying reversion is derived from direct infection experiments. In Table V are shown the results obtained by infecting healthy pot plants with mite. There are six cases where an attempted infection produced reversion in the plant and three cases where Big Bud was produced, but no reversion, and six cases where no Big Bud and no reversion were produced. Thus where no Big Bud followed no reversion was obtained and from eight successful Big Bud infections, only five successful reversion infections followed; where reversion was produced in two cases it appeared in the same year, and in three cases in the following year. The numbers in this experiment are admittedly very small and certainly too much reliance must not be

placed on them. They do appear to show, however, that a successful infection of Big Bud is followed by reversion, though not necessarily in the same year in which the Big Bud appears and certainly not usually in the year of mite infection. The contention is supported by a field trial where on 15 healthy Edinas 10 infections of mite were made. In the first year one of the bushes showed typical mite revert foliage (tomato leaf type, Pl. XIV, fig. 6.) The result has already been obtained by Massee at East Malling and in this respect this infection confirms his claim. The Long Ashton field infection trial will need to wait for a year or two more before conclusions can be drawn.

Summing up the evidence, it would appear that mite infection may produce reversion (either directly or by being a carrier) though there are many cases to be found where no reversion has followed the appearance of Big Bud. It is obvious that further work is necessary on these points, especially in respect of testing possible reversion carrying power of mite.

Whether subsequent experiments prove that mite does or does not carry reversion infection does not affect the possibility that arthropods other than mite may be carriers. Black currants are attacked commonly by two species of aphis and also fairly frequently by capsids.

TABLE V.

Relation of Mite Infection to the Production of Reversion.

	Big bud appeared in			Reversion appeared in			Reversion did not appear
No.	1st year	2nd year	3rd year	1st year	2nd year	3rd year	
5	.	×	.	.	.	×	.
8	×	.	.	.	.	×	.
10	.	.	×	.	.	×	.
11	×	.	.	.	×	.	.
29	×	.	.	×	.	.	.
30	.	.	.	×	.	.	.
37	×	.	.	.	.	.	×
38	.	×	.	.	.	.	×
43	×	.	.	.	.	.	×
6 cases did not appear			.	.	.	.	×

The case for aphis is suggestive. It is at least remarkable, as pointed out in that part of the paper dealing with statistical results, that a bad aphis year was followed by a sudden marked increase in the number of new reverts (1 per cent. new cases in 1923, 13 per cent. in 1924, in round figures). I am indebted to Mr. W. P. Seabrook for a similar observation bearing out this contention. In 1918 in his experience a bad attack of aphis was followed by a very marked increase of reversion. In a bad year the pest is never completely controlled and consequently winged parthogenetic females are produced in numbers. In a mild year by the time these are due to appear spraying and natural enemies have usually greatly reduced the number of parent aphids. Consequently but few winged forms appear. It is of course only winged forms that can convey disease

from revert to healthy bush since the wingless ones do not move from bush to bush.

There is, however, as yet no direct proof, but it will be the aim of future experiments to test whether mite, capsids or aphis be carriers of the disease.

Summary.

(1) This paper is a continuation of previous work on Reversion Disease of Black Currants, and deals more especially with the possible means of infection.

(2) Evidence is put forward showing that the disease can be propagated by contact of diseased material with healthy, either by grafting or by pruning with a contaminated pruning tool.

(3) The disease, after it has attained entry, is propagated slowly downwards.

(4) The rate at which it travels appears to depend on the intensity of the original infection, and there is some evidence to show that the intensity of the resulting disease is also similarly dependent.

(5) Propagation can be independent of Black Currant mite, *Eriophyes ribis*.

(6) There is no evidence of occurrence of the disease solely on the ground of proximity of healthy and infected plants.

(7) There is some evidence in support of the possibility of a pest carrier.

Explanation of Plates.

Fig. 1. Effect of grafting revert graft on healthy black currant plant. The graft has died, but the shoot nearest graft has become revert, the other shoot being still healthy at the time of photographing.

Fig. 2. Ditto. Shoot nearest graft strongly revert, next shoot moderately revert, farthest shoot still healthy.

Fig. 3. As Fig. 1, but not quite so marked.

Fig. 4. Effect of pruning with contaminated knife. The two shoots behind the snag strongly revert, the shoot issuing lower down still healthy. This is a plantation bush and the effect was obtained accidentally.

Fig. 5. Shoot bearing heavy crop with revert foliage, showing that the infection took place too late to infect the flower buds.

Fig. 6. Effect of a heavy artificial infection of mite. The infected shoot has produced revert leaves of the tomato type.

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Fig. 1.

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FIG. 2.

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FIG. 3.

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Fig. 4.

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Fig. 5.
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FIG. 6.

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TAR DISTILLATE WASH TRIALS IN THE BRISTOL PROVINCE.

By A. H. Lees and L. N. Staniland.

During the last four years numerous experiments have been made at the Research Station in connection with tar distillate washes. The work at first was chiefly small scale experiments, but a few field trials were also included. Towards the end of 1924 it was felt that the time had come for much more extensive trials to be done. With the co-operation of the various County Staffs concerned, an extensive programme was devised and the results are embodied below. The main object of the experiment was to obtain precise information on certain proprietary brands recently put on the market which, for the purpose of this article, are lettered A-E. A similar series of trials were made at the same time in the West Midland Province by the Harper Adams Agricultural College in conjunction with the County Staffs of Shropshire, Staffordshire and Warwick. The results were almost identical with those obtained for the Bristol Province.

In the Bristol Province seven different plantations were included, two in Gloucestershire, two in Herefordshire, one in Somerset and two in Worcestershire. Most of the trees treated were apples, but plums were also represented.

In order to minimize experimental error the plots were chequer-boarded where possible. Each sub-plot, in such cases, consisted of either four or six trees, and the same treatment was given to three separate sub-plots scattered in different parts of the whole plot.

Two strengths for each brand were used, 4% and 8%. For the purpose of estimating results every tree of every plot was inspected by two independent observers.

It was originally intended that observations on the effect of these washes on fungus diseases should be made at the same time as those on insect pests, and the co-operation of the Advisory Mycologist was obtained. Unfortunately, conditions did not admit of positive results being secured for fungus diseases, and, accordingly, the results below apply only to insect pests.

Description of Plantations and Trials.

Place of Plantation.	Fruit.	Arrangement.	Time of Application	Date of Exam.
Huntley, Glos.	Plums. Blaisdon.	Chequered. Plots of 4 trees 3 times repeated.	Feb. 2-3.	Apr. 27.
Evesham, Worcs.	Plums. Pershore & Victoria.	Chequered. Plots of 4 trees 3 times repeated.	Jan. 19-20.	May 1.
Hambrook, Glos.	Apples. Mixed.	Chequered. Plots of 4 trees 3 times repeated.	Feb. 1819.	May 11.
Marden, Hereford.	Apples. Newton Bramley.	Treatments in rows. Control chequered.	Feb. 27.	May 13.
Holmer, Hereford.	Apples. Mixed.	In rows.	Mar. 2.	May 13. No pests present.
Wiveliscombe, Som.	Apples. Mixed.	Chequered. Plots of 6 trees 3 times repeated	Feb. 10-12.	May 15.
Bransford, Worcs.	Apples. Mostly Worcesters.	In rows.	Jan. 13.	Ap. 30.

In the tables showing the effect of the sprays a marking has been given to indicate the prevalence of each pest under observation. The maximum marking is 10 and represents "very bad." A "trace" is represented by the marking 1, "slight" by 3-4, "moderate" by 5-6, and so on.

The column marked average represents the average marking for the particular pest concerned.

Bristol District.

Plum Trials.

	4% Strength. Aphis.			Caterpillar.			8% Strength. Aphis.			Caterpillar.		
WASH.	E.	Hu.	Av.	E.	Hu.	Av.	E.	Hu.	Av.	E.	Hu.	Av.
Control	1	1	.5	1.3	2	1.7			.5			1.7
A.	0	0	0	1	2	1.5	0	0	0	1	0	.5
B.	0	0	0	2	0	1.0	0	0	0	1	0	.5
C.	0	0	0	1	1	1.0	0	0	0	1	0	.5
D.	0	1	.5	1	2	1.5	0	0	0	1	1	1.0
E.	1	2	1.5	2	2	2.0	0	0	0	1	2	1.5

The names of the places are indicated by letters. B—Bransford, E—Evesham, H—Hambrook, Hu—Huntley, M—Marden, W—Wiveliscombe.

APPLE TRIALS.

8% Strength.

	APHIS.					PSYLLA.					CATERPILLAR					CAPSID.				
WASH.	H	M	W	B	Av.	H	M	W	B	Av.	H	M	W	B	Av.	H	M	W	B	Av.
Control	8	.6	2	4	3.6	6	9.2	2	9	5.2	4	5.2	2	1	3.0	2	3.2	4	3	3.0
A.	0	0	0	0	0	0	0	0	0	0	2	2	1	0	1.2	0	0	0	2	.5
B.	0	0	0	0	0	0	0	0	1	.2	3	1	1	0	1.2	0	1	1	2	.7
C.	0	0	0	1	.2	1	0	0	2	.7	2	2	1	0	1.2	1	1	2	1	1.2
D.	0	0	1	2	.7	2	0	0	3	1.2	2	2	1	0	1.2	2	1	4	2	2.2
E.	1	0	2	5	2.0	4	6	1.5	8	4.9	4	4	1	0	2.2	2	4	4	3	3.2

APPLE TRIALS.

4% Strength.

	APHIS.					PSYLLA.					CATERPILLAR.					CAPSID.				
WASH.	H	M	W	B	Av.	H	M	W	B	Av.	H	M	W	B	Av.	H	M	W	B	Av.
Control	8	.6	2	4	3.6	6	9.2	2	9	5.2	4	5.2	2	1	3.0	2	3.2	4	3	3,2
A.	0	0	0	0	0	0	1	0	0	.2	3	4	2	0	2.2	0	1	2	2	1.7
B.	0	0	0	0	0	0	0	0	1	.2	3	2	2	0	1.7	0	2	–	2	1.3
C.	0	0	1	1	.5	1.5	0	0	3	1.1	4	2	1.5	2	2.4	2	2	4	1	2.2
D.	0	0	2	3	1.2	2	1	0	7	2.5	–	4	2	0	2.0	2	2	4	2	2.5
E.	2	0	2	7	2.7	6	8	0	9	5.7	4	6	2	0	3.0	2	4	4	3	3.2

* As two varieties, Bramley and Newton, were present at Marden, separate controls were kept for each variety. This necessitated the use of decimals to express the average control.

Conclusions.

Plums.

Effect of 8% strength :—

Aphis.—The attack was never more than a trace, which was effectively dealt with by all brands.

Caterpillar.—The attack was very slight. Washes A, B and C made an effective reduction in numbers while the effect of D and E was barely distinguishable.

Effect of 4% strength :—

Aphis.—All brands were effective except D and E.

Caterpillar.—No marked result was obtained, washes B and C being the best.

Apples.

Effect of 8% strength :—

Aphis.—The controls were slightly attacked. Washes A, B and C gave practically complete control, the result with D was good, E had but a slight effect.

Psylla.—The controls were moderately attacked. A and B gave practically complete control, C a good control, D was rather less effective than C, and E was ineffective.

Caterpillar.—The controls were slightly attacked. All except E reduced the infestation by rather more than half.

Capsids.—The controls were slightly attacked. A and B very considerably reduced the infection, C reduced it to less than a half, while D and E did no material good.

Effect of 4% strength :—

Aphis.—Washes A and B were as effective at this strength as at 8%, C was only slightly less effective. D had some action, and E very little.

Psylla.—A and B were practically as effective as at the 8% strength. C gave good control, D reduced the infection to a half, and E had no apparent action.

Caterpillar.—No satisfactory control was obtained with any brand, and the comparative merits are shown by the figures in the table.

Capsids.—The control effected at this strength by even the best brand was not more than moderate. The figures in the table give the relative order.

Conclusions as to General Efficiency of the Washes.

When considering the value of a wash to the fruit grower it is not advisable to confine attention to any one pest, however important. It may well be that one pest may be completely or nearly completely controlled by a wash which may be of little service in controlling other pests. In such cases, its ultimate value to the grower reckoned in profit accruing from its use may be a small one, and another wash, giving less complete control of the pest first considered, but more complete control of other pests may, in the long run, prove to be the better when considered purely from the financial point of view. In these trials, both A and B washes have given very good results, and, taking the broad view, it is difficult to distinguish between them. Against Caterpillar and Capsids at 4% strength the washes were not of much use, but at 8% considerable control of Capsids and partial control of Caterpillar were effected. It should be noted, however, that it is quite possible that some moths laid eggs after the application of the wash. No attempt was made to distinguish different kinds of Caterpillars.

On the question of possible damage, these trials have not given very clear evidence. In some cases flowering appeared to have been stopped by the wash used. A closer examination afterwards, however, suggested that other causes had been at work, causes quite independent of spraying, but sometimes working in the same direction.

No doubt the time of application is important, especially in the case of plums, though it is not possible to draw any exact conclusions from these trials. The writers, however, hold the opinion from the experience gained in this work that plums should not be sprayed later than the middle of January, and apples not later than the end of February.

On the whole, in these tests the two brands A and B proved themselves clearly superior to the others which were tried.

It should, however, be clearly understood that these results refer only to the particular samples used and to the particular season (1924-25) in which they were tried. From the nature of the case it is impossible to obtain from one year's trial information that is directly applicable to the following year. There is no certainty that a wash that is good one year will be good the next year. Experience has indeed shown that in some cases the opposite takes place, and that, therefore, it is impossible to give a grower advice founded on one year's trial only. Nevertheless, cumulative evidence should be given due weight and brands that give consistently good

results year after year merit a higher recommendation than those not doing so. To technical officers at the Research Station there are also other sources of information available, and it is often possible for them to give reliable advice to any inquirer, though such advice cannot always be entirely based on statistical data. For this reason, therefore, it is suggested that growers requiring further information on this matter should communicate with the Research Station.

ON THE DISEASES KNOWN AS "BARK CANKER" AND "DIE BACK" IN FRUIT TREES.*

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Introduction.

The term "Die Back" appears to be of American origin, and according to Stevens and Hall (20) it was first used by Rolfs in 1907 to describe a disease of peach and Japanese plum trees in Missouri. The name "Die-back" was descriptive of some symptoms of the disease which was characterised by a wilting and killing of twigs and branches, which commenced at the tips and progressed downwards to the larger limbs.

Considerable literature has accumulated on the subject of "Die Back" disease in different host plants, a list of which is given at the end of this paper.

It is not proposed to give detailed descriptions of the fungi *Myxosporium corticolum Edgert*, *Cytospora spp.*, and *Diaporthe perniciosa Marchal*, which are mentioned in this paper, since full accounts of these organisms have previously been given by Miss Gilchrist (5), Wormald (23), and Miss Cayley (2), respectively.

Object of Investigation.

In the United States (11) the fungus *Myxosporium corticolum* is responsible for the superficial bark-canker of the apple and the pear. The fungus *mycelium* grows in the outermost bark tissues only, and it does not reach the cambium. Its progress into the tissues is arrested by a layer of cork developed by the plant in response to the stimulation induced by the invading fungus. The affected tissue is killed and eventually it sloughs away. Fruiting bodies, acervuli, are formed just beneath the surface of the bark. The damage caused by the fungus is so slight that it is doubtful if any remedial measures are ever necessary or profitable.

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Wiltshire (21), followed by Miss Gilchrist (5), working on a " Die Back " disease of apple trees, came to the conclusion that it was due to *Myxosporium corticolum*. There is considerable difference between the disease as described by them and the Superficial Bark Canker of the United States, although the causal organism in both cases is the same. In England the wood is affected, whereas, in the United States only the outer cells of the bark are affected, hence the name Superficial Bark Canker. To indicate this difference both Wiltshire (21) and Miss Gilchrist (5), called the disease Bark Canker, and omitted the word Superficial, since it did not apply in England. This has led to some confusion, since the disease in England is a " Die Back " and its cause, as will be shown later, is the same as " Die Back " in other fruit trees. The present paper has as its object the clearing up of the confusion between Superficial Bark Canker, Bark Canker, and " Die Back " in fruit trees, both in regard to the primary causes of the disease on different hosts, and the control measures to be taken against the disease.

The Disease in Apple and Pear Trees.

The external appearance of the disease in apple trees is characterised by a longitudinal splitting on each side of an area of bark ½ to 1½ inches broad. The disease progresses very rapidly, and in a few weeks the splitting of the bark may extend for the whole length of a main branch five to six feet in length The disease may start at any portion of the branch, and in one case developed on the trunk of the tree just above soil level. In the latter, it caused the rapid death of the whole tree, whereas in the former, individual branches are killed one after the other. In contrast with the extremely rapid advance of the disease in a longitudinal direction is its very slow development transversely. Girdling of a limb is very slow. The bark between the two longitudinal splits later becomes sunken owing to the shrinking of the underlying tissue and the cessation of growth of the wood in the affected region due to the death of the cambium. The wood underlying the sunken area of bark is brown in colour to varying depths up to half an inch or more. Microscopic examination shows the presence of fungus hyphæ in the cortex, wood vessels, and medullary rays. As the bark is killed it invariably becomes covered with small raised black specks. These specks are the fructifications (acervuli) of the fungus *Myxosporium corticolum* Edgert. When mature a tiny slit appears in the bark at the centre of each speck. In moist weather the spores of the fungus (Plate I, fig. 2*d*) are liberated through the tiny slits and can be seen with the naked eye as white points. These are washed down the branches and trunks of the trees by rain. After the spores have

been liberated, the acervuli appear as tiny, black, elongated and shallow pits. As stated by Miss Gilchrist (4) the disease is active only towards the end of the summer. The symptoms and development of the disease on pear trees are similar to those on apple trees. The bark splits longitudinally and is always followed by the production of innumerable acervuli of the fungus *Myxosporium corticolum Edgert.* The underlying cortex and wood take on a brown discoloration and are invaded by fungus hyphæ. In spite of the extremely regular occurrence of the fructifications of *Myxosporium corticolum* on the diseased bark of both apple and pear, it is difficult to regard this fungus as the cause of the disease. Over a dozen cultures have been made from time to time from the innermost diseased wood underlying the sunken bark of several affected branches, and on no occasion has *Myxosporium corticolum* been obtained in cultures. The fungus which grows in cultures of such diseased wood is always *Diaporthe perniciosa Marchal.* Cultures from the outermost diseased wood yield generally a mixture of *Myxosporium corticolum* Edgert, and *Diaporthe perniciosa* Marchal. When the disease has advanced and the tissues are drying up, pycnidia of *Diaporthe perniciosa* are often produced on the bark. Both *Myxosporium corticolum* and *Diaporthe perniciosa* produce conidia in culture. In the many cultures of *Diaporthe perniciosa* grown from diseased apple wood and the pycnidia on the bark, which the writer has always found to contain " a " conidia only, the fungus generally produces pycnidia with " a " type of conidia only, but in a few cases, both " a " and " b " types have been obtained in cultures made from " a " pycnospores. The " b " type as well as the " a " type are often formed by the fungus isolated from the plum, pear and cherry laurel (Plate I, Figs. 2*a* and *b*). The " a " conidia of *Diaporthe perniciosa* resemble somewhat in shape those of *Myxosporium corticolum.* The former, however, are much smaller, being only 7-9 × 2-3, whilst the conidia of *Myxosporium corticolum* measure 16-39 × 5-11. The fungus *Myxosporium mali* Bres. mentioned by Miss Gilchrist has not been found by the writer. Mr. R. M. Nattrass and Mr. F. E. V. Smith have subsequently made cultures from the innermost diseased wood on apple and pear trees. As with the writer, the fungus was found to be *Diaporthe perniciosa* Marchal. In view of the results obtained by culturing the underlying wood, Mr. Smith and the writer together made a detailed examination of the bark of apple and pear trees in the plantations at Long Ashton. They found that *Myxosporium corticolum* occurs on the bark of all varieties of otherwise healthy apple and pear trees which are twenty or more years old. Subsequent examinations of apple and pear trees throughout the western counties also showed that *Myxosporium corticolum* is always to be found on the bark of older trees.

Superficial Bark Canker

The fungus *Myxosporium corticolum* as it occurs on the bark of otherwise healthy trees, agrees with the above description of the Superficial Bark Canker (11) and (24) in the United States. The fungus attacks the outer bark of the trunk and larger limbs generally, but sometimes occurs on the damaged bark of the younger branches. The disease can be recognised at some distance by the reddish or bronze colour and the slightly sunken appearance of the portion of bark attacked. The affected areas range in size from small areas of a few millimeters only in diameter, to large patches measuring several inches across. These patches often coalesce and eventually the whole trunk is covered, so that it is extremely likely that the normal roughening of the bark in mature apple and pear trees in this country is due, in great part, to the activities of this fungus. Affected areas become covered with the innumerable fructifications of the fungus. The fungus hyphæ never penetrate beyond the few outer layers of the bark cells, and as is found in America, it never reaches the cambium. The affected layer of bark is separated from the healthy by cork cambium, which afterwards becomes suberised. Later, the outer bark can be easily peeled off with the hand. As a disease, it does not warrant consideration by the grower, and it is questionable whether the fungus is not, in some cases at any rate, beneficial, since it gives the softer tissues underlying the outer bark a chance to expand in growth, thereby lessening the danger of the tree becoming bark-bound. Growth splits which occur in branches and trunks of trees in some seasons often become infected with *Myxosporium corticolum*, but its activities are confined to the outermost layers of bark. This stimulates the tree to the formation of corky tissue underneath and this quickly closes a wound which otherwise might be open to infection by a serious fungus parasite, such as the silver leaf organism (*Stereum purpureum*) or the canker fungus (*Nectria galligena* Bres.). Cases of infection of growth splits by the latter fungus have been observed.

The following infection experiment on apple trees using *Myxosporium corticolum* and *Diaporthe perniciosa* separately, and together, as inocula has been carried out. The variety of apple trees used was James Grieve. In all cases a slit in the bark and wood was made with a sterilised scalpel, and mycelium from pure cultures of the fungi was introduced with a sterilised needle, and the wound was then bound with raffia. Six trees were selected and six branches of each used for the experiment. Five branches of each of the trees were inoculated, and the sixth branch served as a control in each case. The branches of two of the trees were inoculated with *Myxosporium corticolum*: the branches of two others were inoculated with *Diaporthe perniciosa*: and the branches

of the remaining two with mycelium of both *Myxosporium corticolum* and *Diaporthe perniciosa*. The two fungi were used together because, at the time, it was thought that possibly one of the two fungi paved the way for the other, although any one of the two alone could not produce the disease. None of the inoculations succeeded in producing symptoms of the more serious disease of " Die Back," formerly known as Bark Canker, which is characterised by the longitudinal splitting of the bark. In almost every case, including the controls and those inoculated with *Diaporthe perniciosa* only, fructifications (acervuli) of *Myxosporium corticolum* developed on the injured portion of the bark. This infection experiment gave negative results in spite of the fact that inoculations were made at the end of August, 1923, at which time of the year the disease commences to become active again. The negative result of this experiment is very significant. Observations of the disease as it occurs in the field show that in all cases where the disease occurs on apples and pears, the trees are in an unhealthy condition from some cause or causes before infection by *Diaporthe* can take place.

The Disease in Stone Fruit Trees.

As in the case of apple trees the symptoms of the disease vary according to the point at which the disease commences. If it starts at a wound on a branch the same longitudinal splitting and sinking of the bark is noticeable, particularly in the plum, although the bark does not split to anything like the same extent in stone fruit trees as in apple trees. In all the host plants callus is formed by the healthy tissue bordering on each side of the sunken area of diseased tissue. The bark of the diseased area takes on a reddish colour and eventually becomes covered with the fructifications of *Cytospora* sp., or *Diaporthe perniciosa*, or more commonly with a mixture of both, particularly in the plum. Where extensive bark splitting does not occur the branches become somewhat flattened on one side. This is due to the cambium being killed on one side, and therefore further production of wood at this region is impossible, whereas growth continues in the unaffected portion of the branch. The splitting of the bark is usually accompanied by an exudation of gum. The wood, below the sunken area of the bark is brown to more or less an extent depending on the degree to which the disease has developed.

Microscopic examination shows the presence of gum in the tissues, particularly the wood vessels and medullary rays. Fungus hyphæ may or may not be found present in the vessels of the wood. It has been observed that vessels whose cavities are completely filled with gum or tyloses do not contain fungus hyphæ. This is so marked that it strongly suggests that fungus hyphæ cannot

penetrate readily through the gummy substance. Wound gum is probably, therefore, a deterrent to fungus infection. Branches and trunks of trees of all ages are subject to the disease. In the case of young trees which are generally attacked in the main stem, the fungus *Diaporthe perniciosa* usually gains entrance at the point of union of stock and scion, and sometimes through a large and incompletely healed wound. The disease girdles the stem and the tree dies from below upwards. In the field generally the first noticeable sign of the disease is the sudden browning and wilting of the leaves in midsummer, and soon afterwards the tree is killed. Later, the diseased areas become covered with fungus fructifications. These often develop whilst the branch or tree is still alive, provided the disease is confined to one side only. If the branch or trunk is completely girdled, fructifications appear after the tree has been killed. Several organisms are found in association with the disease on stone fruit trees. These include the fungi *Cytospora* sp., *Diaporthe perniciosa*, and in the case of few of the plum trees examined, *Myxosporium corticolum*. In the case of one plum tree about eight years old the fungus *Cryptosporella prunicola* Oud. was found. The identification of this fungus was made for the writer by Miss E. M. Wakefield at Kew. Owing to the fact that the perithecia of this fungus were found very closely associated with the pycnidia of *Cytospora* sp., it was at first thought that it might be the perfect stage of *Cytospora* sp. Cultures of both, however, proved beyond doubt that this was not the case. Only the perithecial stage of *Cryptosporella prunicola* Oud. were found. Masses of rod-shaped bacteria which agree with those described by Wiltshire (21) are also found in the plant tissues. These bacteria are generally confined to the area between the healthy and diseased tissues and are exuded as light yellowish beads when the overlying bark is pressed with the thumb. As previously stated, it is at these points that the splitting occurs. What appear to be the same bacterial masses occur in peach and cherry as well as in the plum. Attempts to grow the bacteria in pure culture on artificial media have failed. These bacteria have not been observed on apple, pear or cherry laurel suffering from the disease. The only organism which is constantly present in diseased tissue in all host plants is *Diaporthe perniciosa*. On young plum trees the fructifications of *Diaporthe perniciosa* are generally confined to within a few inches of the area whence the disease started, which in the majority of cases is low down on the stem at a wound or the point of union of stock and scion. The main stem above is covered with the fructifications of *Cytospora* sp. Portions of the sunken area of the bark of the cherry laurel were carefully incubated and examined for fungus fructifications, and the only ones found were the pycnidia of *Diaporthe perniciosa*. Both Mr. Nattress and the writer made

several isolations from the diseased wood, and except where contaminations by species of Penicillium occurred, all yielded pure cultures of *Diaporthe perniciosa* to the exclusion of *Cytospora* sp., *Myxosporium corticolum* and bacteria. From the above it seems more than likely that, under certain conditions, the fungus *Diaporthe perniciosa* can produce the disease in all the host plants mentioned without the aid of bacteria, *Myxosporium corticolum* or *Cytospora* sp. On the other hand, the writer considers that although the fungus *Cytospora* sp. is a weaker parasite than *Diaporthe perniciosa* it, nevertheless, is sometimes independently, but more often following *Diaporthe perniciosa* a contributing factor in the killing of the plant. Furthermore the evidence of this paper proves that *Diaporthe perniciosa*, although the stronger of these two, is, nevertheless, also a weak parasite and cannot infect a healthy tree, but only those seriously enfeebled by one or more factors such as those discussed below. The general impression of the writer is that the bacteria are not pathogenic, but their presence cannot be entirely ignored. If, at some future date, they are proved to be weakly pathogenic, it will make no difference to the conclusion drawn in this paper.

Evidence of Weak Parasitism of Diaporthe Perniciosa.

On Apple Trees.

The row of apple trees (James Grieve) on which the disease has mostly been studied by Wiltshire (21), Miss Gilchrist (5) and the writer, are twenty years old, planted ten feet apart, with the same distance between the rows, and main branches are covered with large *Nectria* and Scab cankers, as well as American blight. Furthermore, the variety is a heavy cropper and the trees have of late years, purposely not been freely manured. The trees were, in the first place, planted for intercropping purposes between standard orchard trees, but it was decided to keep them as material for experimental purposes. The fruit and leaves borne are small in size for the variety, which is another clear indication of lack of vigour. Wiltshire (21) also remarked on the poor condition of these same trees. Some of the branches have been cut back from time to time and have become infected with *Diaporthe perniciosa*, which under these conditions is capable of becoming a serious parasite. There was not sufficient vigour in the trees to push out the dormant buds below the point to which the branches were cut back. Had the trees been able to do this, the probability is that they would not have contracted the disease to any serious extent. The disease has also been observed elsewhere on pear trees about twenty years old, which were completely neglected during the war, and are badly attacked by both canker (*Nectria ditissima*) and Scab (*Venturia pirina*). During the war no cultivation of any kind was done, and since then

they have received very little manure. Several young trees of different varieties were pruned in the early spring of this year, and since then they have been under close observation. In the normal course of events the pruned end dies back as far as the next bud below it. The great majority of these snags became infected with different fungi, including *Diaporthe perniciosa* and *Cytospora* sp., but, nevertheless, the twigs did not as a rule die back further than the next bud. In rare cases, the twig or branch died back to the second bud, and was infected to this point with *Diaporthe perniciosa*, *Cytospora*, and other fungi. The cause of this was invariably found to be due to damage of the uppermost bud. The trees in question were robust, and healthy plants which had been liberally and regularly manured. Similar observations have been made on fruit trees elsewhere. The disease never progressed further than the point at which a new shoot was formed. If *Diaporthe perniciosa* and or *Cytospora* sp. are the primary cause of disease, it is difficult to understand why they do not kill the branches after gaining entrance into the tissues.

Three young apple trees which had been growing in pots for three years were transplanted into the open in the spring of this year. Early in June, when the trees were in leaf, they were given with other foodstuffs, a dressing of sulphate of ammonia. One of the trees was inadvertently given too heavy a dressing with the result that the roots were damaged and a few days later the leaves turned brown and the tree was defoliated. The tree later put out a fresh crop of leaves, but before it had recovered from the drastic treatment of three years of pot life, a transplanting in the spring, followed by a severe root damage due to the sulphate of ammonia, it contracted the disease described above. The disease did not appear in the other two trees, which remained comparatively healthy.

Apple trees are subject to a dying back of twigs and branches said to be due to *Cytospora* sp. The writer has never found this form of " Die Back " disease, except in cases of trees or individual branches enfeebled by some other disease or physiological disturbance.

On Plum Trees.

Early in the summer of 1923, two unusually tall standard plum trees (some of the stems 7ft. 6ins. in height) about nine years old, were sent to the writer from the Evesham district. The trees were dying, although the uppermost branches were still living and were bearing yellowish green leaves. Very little growth had been made in that year. The lower part of the main stems were dead and covered with pycnidia of *Cytospora* sp. and *Diaporthe perniciosa*.

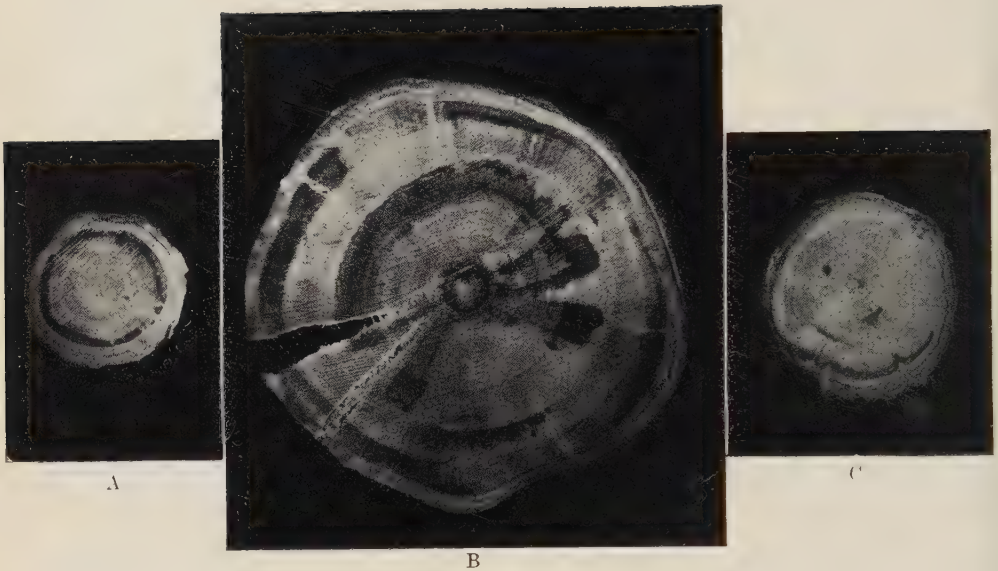

FIG. 1.
PLATE I.

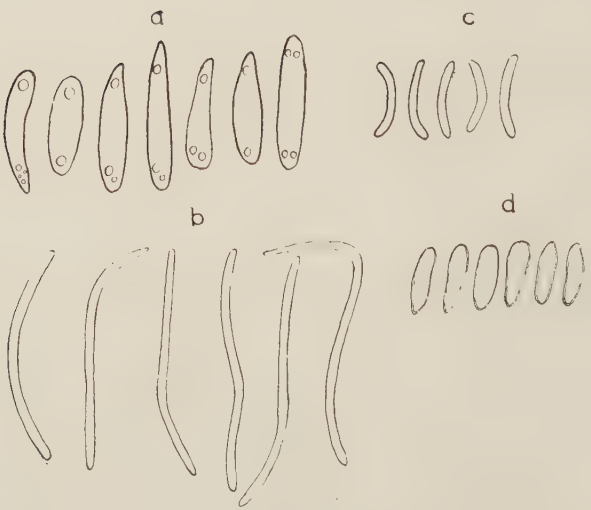

FIG. 2.
PLATE I.

The roots were all brown, dead and water-logged. The condition of the root system suggested bad drainage. The trees were seen by Mr. Locke, Foreman of the above Station, who recognised the trees on account of their exceptionally tall stems, as some he had planted some years ago in a low lying and badly drained orchard near Evesham. Mr. Locke states that, at the time of planting, he was convinced that they would not do well in that orchard. The soil in the orchard was later examined by the Station Soil Chemist, Mr. Wallace, who describes it as follows :—

> " A water-logged tract consisting of a surface layer of peaty material overlying a bed of impervious Blue Lias Clay."

The remaining plum trees in the orchard are not looking healthy, and some show signs of infection by *Diaporthe perniciosa*. This is a clear case of trees, whose history is known, becoming enfeebled on account of bad drainage and killed by subsequent infection of *Diaporthe perniciosa*, followed possibly by *Cytospora* sp.

Plate I, fig. 1A, shows a cross section of the main stem of a young plum tree which was in a dying condition. The roots as in the above case were brown throughout. The tree was uprooted in the summer of 1923. The wood formed in 1923 is comparatively clean as compared with the deeply stained wood formed in the previous year 1922. The brown discolouration is due to the presence of gum in the wood vessels. Gum was present also in the medullary rays and cortical tissues. Discoloured wood of this kind is not invariably invaded by fungus hyphæ. The browning of the wood is either the result of the reaction of the plant to the actual presence of hyphæ at this point, or due to toxic substances produced by the fungus in tissues lower down on the stem and carried up through the vessels. In either case, if the primary cause of the disease is due to infection by one or more fungi, or other organisms, it is more than probable that, after getting such a hold on the plant as to affect the wood formed during the whole of a growing season, the organism would have continued to do so in the following season. The only possible explanation is that the fungus is a weak parasite and its growth in the plant tissues has been checked in 1923 owing to a drastic change taking place in the environment of the plant. This in some cases is undoubtedly correlated with the amount of rainfall. Plate I, fig. 1B, shows this very clearly. The cross section shown is of the main stem of a plum tree, one branch only of which was dead. The roots were examined and only one large root was found to be completely brown. The tree had been grown in the same position in the plantations of the Research Station, East Malling, Kent, for several years. The tree was, through the kindness of Mr. Hatton, cut down for examination in 1923. It will be seen that the disease had been present for some years. It

is significant, however, that during one year, namely 1921, the tree formed more and cleaner wood than in any other year. It is common knowledge that in the year 1921, the summer in England was exceptionally hot and dry. Plate I. fig. 1c, is a cross section of the main stem of a young plum tree which again shows seasonal activity of the disease.

Several plum trees have been examined and found to be in an advanced stage of the disease, and the roots have been found on cutting, to be clean and healthy looking. This was particularly so in the case of plum trees brought in from another fruit farm in the Evesham district. The trees were growing on light gravelly soil on a hill. In a normal year the soil dries out to a considerable depth in the summer. It is well-known as one deficient in potash, and in consequence the apple trees in the plantation suffer from serious scorching of the leaves. Plum trees of seven or eight years old can be shaken from one side to the other with one hand. Unpublished experiments with willow cuttings by Wallace and Hutchinson at the above Station indicate that there are considerably more fibrous roots produced by plants growing in nutrient media containing potash than are produced by those grown in a medium deficient in potash salts. It is easily understood, therefore, that trees growing in gravelly soil deficient in potash cannot possibly produce a root system capable of absorbing sufficient moisture from a soil which is liable to dry out in summer. The general health of fruit trees can, therefore, be so seriously lowered, not only by excessive soil moisture due to bad drainage, impervious subsoil, etc., but also by insufficient moisture, whether this be due to the physical texture of the soil coupled with, or independent of, potash deficiency, as to make them susceptible to attack by the weak parasite *Diaporthe perniciosa* and possibly other organisms. So far as the root system of a plant is concerned, the effect of a waterlogged soil and a soil too dry is physiologically very similar. In the first case waterlogging asphyxiates the roots so that they are unable to function as absorbing organs ; in the second case the roots are possibly killed through excessive dryness, and in any case they cannot absorb moisture from a soil which has become desiccated beyond a critical point. As already stated, the disease becomes active in the summer, but the pot plant damaged by sulphate of ammonia and alluded to above, contracted the disease early in June after the second crop of leaves had appeared. The production of a second crop of leaves drained the shoot of its reserved food material which further lowered the plants' vitality, and before it recovered as the result of leaf and root activities, the plant contracted the disease. The progress of the disease in this plant was extremely rapid once it started. Miss Cayley (2) states, and Plate

I, fig. 1A, B and C corroborates this view, that "infection occurs a considerable time—in some cases probably years—before any definite external symptoms can be seen; but that, once wilting has occurred, the affected areas die very rapidly . . . ." The reason for this is due in the first place to some physiological factor which upsets the metabolic balance of the tree so that *Diaporthe perniciosa* becomes parasitic. This infection further weakens the plant and usually the cambium is killed within a certain area. Progress of the disease is checked by change of conditions due to change of season or rainfall. The following year, or possibly longer, conditions again become unsuitable to the plant, and the fungus continues growth as a parasite. The rapidity of the advance made by the fungus depends on the degree of unsuitability of the conditions under which the plant grows. In the summer transpiration is at its maximum because the plant is in full leaf. The roots of trees growing in either too wet or too dry conditions from any cause cannot absorb sufficient to keep up the claims made on them by the transpiring leaves, and the fungus under these conditions is able to kill further areas of cambium. The death of more and more cambium, and of wood in the same region, from year to year narrows down the conducting channels between roots and shoots in an upward and downward direction. The effects of the primary and secondary (*Diaporthe perniciosa*, etc.) causes of the disease are, therefore, accumulative from year to year until a point is reached when the plant is so enfeebled that *Diaporthe perniciosa* can grow as a parasite much more rapidly, with the result that the last stages of the disease are far more rapid than at the beginning.

Several plum tree branches were artificially infected with Silver Leaf (*Stereum purpureum*) for experimental purposes in the late summer of 1923. In the case of one tree a large branch contracted the "Die Back" disease in 1924, after the leaves had become silvered. Here is a case of the parasite *Stereum* weakening a branch to such an extent that *Diaporthe perniciosa* is able to cause a secondary disease. Mr. Nattrass informs the writer that he has observed similar cases elsewhere where Root Rot caused by *Armillaria mellea* was the first cause of the disease.

On Young Plum Stocks.

The disease is often present in young stocks before any budding or grafting is done. An interesting and convincing case occurred at Long Ashton this year. The stocks (variety Blaisdon Red) were bought and planted out in rows in the autumn of last year. At the time of planting they were in a very poor condition, although there was no sign of "Die Back" disease present. In the spring of this year some of the plants failed to make any growth at all, whilst the others succeeded in doing so. Early in the year

some of the failures were pulled up and thoroughly examined. The stem tissue was clean and healthy looking, but the stub below ground was brown and showed no sign of new root formation. Later in the summer another lot of the plants which had produced no growth were examined and found to have made no new roots. The stems were dead and the bark covered with fructifications of *Cytospora* sp., *Myxosporium corticolum* and *Diaporthe perniciosa*. Plate II, figs. 1 and 2, shows the correlation between the extent of the disease and the amount of shoot and root growth. This is a case where the development of the disease has been closely observed, and shows clearly that *Diaporthe perniciosa* and possibly other organisms came in as secondary factors. Plate II, fig. 1, Nos. 2 and 4, illustrates the checking of the " Die Back " at the point where new buds have grown out. Plate II, fig. 2, No. 5, shows very slight development of roots coupled with the production of a feeble sucker and side branch.

The disease gets into young stocks as the result of rough handling and an unfavourable season or soil subsequent to transplanting from the stools or layers. The general practice is to dig up or rip up the young stocks and to heel them in before planting. The stocks take some time and often fail to recover, after planting, from this rough treatment, and *Diaporthe perniciosa* and possibly *Cytospora* sp. and other organisms in the meantime are a distinct source of danger. Where hundreds of thousands of young stocks have to be planted out there is a limit, for economic reasons, to the amount of attention that can be given in transplanting. However, it is far sounder to dig up the rooted stools rather than rip them up. In the former, a considerable number of the roots are retained, whereas, in the latter, they are mostly destroyed. Before planting it is also advisable to go over each bundle and trim up the stub and shoots with a sharp knife, making good clean cuts. Further, it is obvious for a number of reasons that in heeling in, care should be taken not to damage the root and shoot with hob-nailed boots.

Another source of danger is in budding, and, if the latter fails, in grafting on stocks too soon. This operation, particularly grafting, which for other reasons is a bad practice, is an additional check before the young stock has become established after moving. In some nurseries the stocks, in preference to the scion, are carried up to form the stem in the case of standard and half standard trees. This is sound for three reasons: (*i.*) It gives the stock time to become thoroughly established. (*ii.*) The union of stock and scion will not be buried below soil level after leaving the nursery and put in their permanent position. (*iii.*) The union callouses over more completely and makes a straighter and therefore stronger stem than when budding or grafting is done low down on thick

Fig. 1. PLATE II. Fig. 2.

and oldish wood. There is a tendency for trees sent out of the nursery with poor root systems to be planted too deeply to ensure good anchorage. This is done in all classes of soil, and is a dangerous and bad practice in heavy land. Plum and other stone fruit trees should not be planted deeply, especially in heavy, wet and cold soils. Trees so planted take a long time to establish themselves in their new quarters, since the whole of the root system must undergo a process of regeneration, and in the meantime *Diaporthe perniciosa* is a source of danger. New roots must be produced higher up where conditions of moisture and aeration are most suitable for growth. Hatton, Grubb and Amos (7), working with apple to investigate the effect of depth of planting on the growth of the tree, state that " (*i.*) the results depend to some extent on the variety of root stock; (*ii.*) seasonal variations affect the results; (*iii.*) the four or five inches difference in depth of planting give an obvious demonstration of the better anchorage of the deeper planted trees." These three points are probably true of plum and other fruit trees and recommendation in regard to the earthing up of young stocks and the planting of young trees must be of a general character. It would be best in all classes of soil to plant as shallow as is compatible with good anchorage. These depths will, of course, differ for light and heavy soils. If the weather in the following growing season is too dry, the plants can easily be earthed up. On the other hand, if the plants in the first place are planted deeply and the season is wet, the soil cannot very well be removed without damaging the plants, and they suffer in consequence. In other words, it is safer within reasonable limits to err on the side of shallow planting of young stock, since in dry weather this can be rectified by earthing up.

On Cherry Trees.

Young cherry trees suffering from the " Die Back " disease were examined by the writer in the summer of 1924. The tops were still living and bearing leaves although in a very weak state. The root system was completely dead and brown. Subsequent inspection of the nursery proved the primary cause of disease to be a soil factor. The surface soil was light and sandy, and to all appearance favourable for growing cherry trees. Within six inches in some cases, and a foot in others, of the surface, the soil consisted of a mixture of almost pure sand and small and large sand stones. The apple trees showed leaf scorch as well as the gooseberry bushes. There has been a certain amount of neglect in hoeing, since a considerable number of roots were damaged and exposed above the surface of the soil. The soil was typical of those which are deficient in potash. The cherry trees still left in the nursery show no sign of " Die Back " disease (no fungus infection)

since tests were made with the knife for diseased cortex. The leaves, however, were purplish and more highly coloured than is normal for the time of year, and in many cases the tissues between the veins were drying out. Here is another case where symptoms of abnormality are apparent before the advent of any weak parasite or parasites.

Occurrence of Diaporthe Perniciosa on Fruits.

So far as the writer is aware, the fungus *Diaporthe perniciosa* has not been recorded previously in this country as a parasite in the orchard on any kind of fruit. This summer, however, a specimen of peach fruit was received by the Advisory Mycologist for investigation. The fruit was attacked by a soft rot, and on the outside of the rotted area there were innumerable fungus pycnidia. These were identified as *Diaporthe perniciosa* and the fungus was isolated from poured plates of the conidia as well as from the internal diseased tissue. At about the same time the writer collected in the plantation at Long Ashton a few undersized and rotting fruits on apple trees (var. Wellington or Dumelow's Seedling). The fruits were attacked by Scab and a soft brown rot. The rotted portion was studded all over with the pycnidia of the fungus *Diaporthe perniciosa*. Poured plates of conidia were made and the fungus obtained in pure culture. Inoculation experiments through wounds were made on both Wellington and Bramley apples. The fungus produced through a wound a soft brown rot and produced pycnidia on the fruit. *Diaporthe perniciosa* was again isolated from the innermost diseased tissue from the four inoculated fruits, and a further inoculation and isolation proved the fungus to be pathogenic. No rot developed in the controls. Recently, diseased fruits of Medlar, sent for investigation, were found to be covered with pycnidia of *Diaporthe perniciosa*. The fungus was isolated from the diseased tissue as well as from pycnospores. Whether or not the fungus is parasitic on Medlar fruits remains to be proved.

Further Evidence of Weak Parasitism of Organisms associated with the Same and Similar Diseases.

The following extracts from different publications by other workers on the same and similar diseases in trees strongly support the present writer's views in regard to the disease known as "Die Back" in this country, with which the fungi *Diaporthe perniciosa*, *Cytospora* sp., and bacterial organisms are associated :—Leonian (13) in his account of an Apple Canker (*Cytospora leucostoma*) in New Mexico, concluded that old and neglected trees are the only ones which can be affected by this organism.

Long (14), working on a disease of Poplars in America, caused by *Cytospora Chrysosperma*, stated that the fungus is a serious parasite under conditions such as the following :—(*a*) On trees which are growing at the outer limit of their range and are therefore in a more or less unfavourable environment ; (*b*) On trees weakened from neglect and lack of sufficient water ; (*c*) On trees severely pruned as in pollarding.

Povah (17), who studied the same disease of poplars in Syracuse, N.Y., states that *C. Chrysosperma* attacked poplars weakened by fire.

Moss (16), who investigated the disease caused by *C. Chrysosperma* in Ontario, states that :—" Younger trees of *Populus deltoides*, especially if seriously injured or weakened, are likely to succumb to the attacks of *C. Chrysosperma*."

Rolfs (18), on Peach trees :

" The age and physical condition of the tree have a marked influence on the extent of injury done by the fungus. Young vigorously growing trees are not seriously injured by it. On the other hand, old neglected trees, especially those standing in sod, are sometimes permanently injured. The real source of danger lies in its attacks on weakened or injured trees, especially those injured by frost."

" Frost, impoverished soil, wet land, lack of moisture, too deep planting, lack of cultivation, wind, fire, or anything which weakens or injures the tissues of the trees aid the organism more or less in its advancement."

Similar evidence can be obtained in the following papers :— Hubert (12), Hahn, Hartley, and Price (6), Hahn (7), Stevens (19), and Hemmi (10).

General Consideration.

It would appear that all or any of the organisms, including the fungi and bacteria, which are found in trees suffering from " Die Back " disease, can only become pathogenic after the vitality of the tree has been lowered on account of some physiological disturbance. It is, in consequence, important to consider what are the factors which cause these internal disturbances within the plant. Some of these have already been partly discussed, namely, excessive soil moisture and insufficient soil moisture. The relationship between soil moisture and the growth of plants is a big question, and it cannot be fully discussed in the present paper. In England, however, as in other countries, the soil is very variable in character, not only in different districts, but often within a small area of an acre or less. Furthermore, the amounts of moisture in these

different types of soils varies according to whether the season is dry, medium or wet. It is evident, therefore, that in soils which normally become very dry in summer, a wet season is advantageous to the plants growing in such soils. Those soils which are normally wet throughout the year, improve so far as the plants are concerned if the summer is dry, as in 1921. In an abnormally wet year, such as the year 1924, soils the moisture contents of which are normally within the range of the plant's tolerance become too wet and the plants suffer. Thus, a dry season might check the progress of " Die Back " disease in some soils, whilst in others the disease progresses rapidly. Apart from the physical nature and condition of a soil—the growth of a plant is also dependent on the chemical nature of the soil. Some contain an excess or insufficiency of lime ; others are deficient in available nitrogen, potassium, or phosphates. Excess or deficiency of any of these chemicals affects the general health of the tree to different extents. In some cases it is extremely difficult to decide what is the factor which affects the growth of the plant. In others the symptoms of the plant are helpful, *e.g.*, Leaf Scorch, Chlorosis. A good many troubles can be avoided by judicious, regular and complete manuring, and a good many can be brought about by neglect of manuring or unbalanced manuring. It needs but little experience to recognise by the tree itself whether it is being overfed or under fed. In addition to carrying a good crop of fruit a tree should make a fair amount of new shoot growth. If this is not done, then it is evident that manuring is necessary. On the other hand, if a fruit tree makes strong new shoot growth year after year and bears no fruit, it is equally evident that the tree wants to be checked (*e.g.*, by ringing, light pruning, clamping, or transplanting) to throw it into a fruiting condition. The amount of manure to be given afterwards will be decided by the amount of fruit borne and the growth made. If unmanured fruit trees are allowed to bear heavy crops year after year, very little new growth will be made, the fruit will be small and the general health of the tree is so lowered that sooner or later it will succumb to one or more diseases.

Most fruit trees are subject to attacks by insects and fungi, and often conditions which favour one may suit the other. A well-known example of this in England is Brown Rot and Aphis attack on plum and other fruit trees. It is common knowledge amongst growers that a bad attack of Aphis and Brown Rot not only may cause complete loss of the crop in the year of attack, but also in the following year and possibly the next. The check to the trees is, therefore, of a very serious nature. During the period which elapses between the attack and recovery, the tree is in a low state, and it is extremely probable that organisms such as *Diaporthe*

perniciosa, Cytospora, etc., can, under such conditions, cause further serious damage to the trees.

In some seasons some varieties of plum trees produce a second crop. This is an unusual procedure for plum trees, but an unusual behaviour of any plant is merely the usual reaction to unusual conditions. In other words, plants never do anything unusual or abnormal, strictly speaking, but are true to their habit by reacting to unusual conditions. Thus a tree does not produce a heavy single crop or a second crop because it is going to die or be weakened, but rather the cause of death or weakening is such that the normally behaving plant produces a heavy or second crop. A sudden, serious, but temporary check in the growing season sometimes causes fruit trees to bear a second crop. The production of this second crop drains the plant of its reserved food material, which cannot possibly be replaced in the short period between the removal of this second crop and leaf fall and dormancy.

It is often desirable to head back trees, or to remove large branches for the purpose of thinning. Some kinds of fruit trees can withstand this form of treatment more than others. Nevertheless, there is a limit to which heading back can be done without affecting the health of the tree, particularly when large limbs are roughly hacked off or cut through with a saw or other blunt implement. It is advisable after removing a branch with a saw to pare the cut end obliquely with a sharp knife or chisel. Branches should also be removed at the base close up to the mother branch or main stem. After paring off, such large wounds should be treated with a wound dressing all over and freshly pared again round the outside edge, so that the inner bark (cambium) is left cleanly cut and in the best condition for quick callus formation.

Hatton (9) finds that different stocks affect the growth of the scion in different ways such as the following :—

(A) Some impart vigour. (B) some have a slight dwarfing effect. (C) certain stocks accelerate the actual time of blossoming whilst others delay it. (D) under the conditions at East Malling some have a firmer anchorage than others. (E) Some stocks seem to show what is described as incompatabilities with certain varieties, whilst for other varieties they may be good stocks. In some cases either buds fail to make in any quantity or sometimes established trees break away at the point of union.

In view of these effects of different stocks on the growth and general behaviour of the scions worked on them, it is possible that a variety worked on one stock may be more susceptible to " Die Back " disease than others. This point is under investigation at the present time at Long Ashton. The remarks given above

in regard to the views of some continental workers on cherry "Die Back," and the effect on time of blossoming found by Hatton (9) is extremely interesting. Some German workers, already mentioned, stated that late spring frosts was the predisposing factor to "Die Back" in cherry. It is possible that the use of stocks which delay the time of blossoming, in districts liable to suffer from late frosts, might be an important factor in the extent to which the disease would occur under those conditions.

Control.

It is generally accepted that healthy vigorous trees are less liable to succumb to disease than those in a weak condition, but so far as "Die Back" disease is concerned a study of the conditions under which the plant grows is all-important before any treatment can be recommended. The predisposing cause may be due to any one or more of the factors mentioned above, and these by no means exhaust the number which can bring about lack of vigour in fruit trees. Growers troubled with "Die Back" in their fruit trees are strongly advised to consult a specialist in the subject of plant diseases, because by so doing they will often be able to avoid very serious losses in their plantations. It is futile to attempt to fight the fungus by direct methods once it has gained entrance into the plant. To remove dead and diseased tissue, if in the main stem, and it usually is, means killing the tree. Even if it were possible to remove diseased tissue without killing the plant, this would by no means cure the disease. On the other hand, the disease can, in the majority of cases, be prevented and checked by the elimination of the primary and fundamental cause or causes which predispose the plant to disease.

In conclusion, I wish to express my thanks to Prof. Barker, Director of the above Station, for his constant and kind direction; to Miss E. M. Wakefield of the Herbarium, Kew Gardens, for identifying and checking the identification of some of the fungi mentioned in this paper; to Dr. G. H. Pethybridge for his kindly criticism and helpful suggestions in regard to the arrangement of the paper before publication; to Mr. W. Camps, of the above Station, for taking the photographs, sometimes at short notice and personal inconvenience.

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EXPLANATION OF PLATES.

Plate I.

Fig. 1. (A, B, and C) shows the effect of season on the development of "Die Back" disease. Sections of Plum trees.

Fig. 2. (*a*) The "a" spores of *D. perniciosa* × 900.
(*b*) The "b" spores of *D. perniciosa* × 540.
(*c*) The pycnospores of *Cytospora* sp. × 1000.
(*d*) The conidia of *M. corticolum* × 300.

Plate II.

Fig. 1. (1) Healthy plum stock (Blaisdon Red).

Fig. 1. (2, 3, and 4). Plum stocks (Blaisdon Red) showing various stages of "Die Back" disease. Note poor root systems.

Fig. 2. (5) Blaisdon stock very badly affected with "Die Back" disease.

Fig. 2. (6, 7 and 8) Blaisdon stocks killed by "Die Back" disease. Fructifications of D. *perniciosa* and *Cytospora* sp. on bark.

EXPERIMENTS ON THE CONTROL OF AMERICAN GOOSEBERRY MILDEW.

By R. M. Nattrass.

As the American Gooseberry Mildew has become a serious menace to the cultivation of the Gooseberry in the Bristol Province, experiments on the control of this disease are now being carried out under the Advisory Scheme of the Ministry of Agriculture.

The following is an account of a trial carried out during the spring and summer of 1925.

The Plots.

The bushes used were of the variety "Whinham's Industry"—this variety being particularly susceptible to the mildew and fairly resistant to spray injury. They were average well grown bushes eight years old, and had been planted in four blocks, twenty-five feet apart, two rows in each, the individual bushes being six by four feet apart. Standard plum trees were growing in between the two rows of bushes in each block.

Each of the four blocks consisted of 48 bushes. The central eight bushes in each block (32 in all) were not sprayed, and these served as a control plot, which traversed the four blocks at right angles. The remaining 40 bushes in each block, twenty on each side of the control, constituted the four plots which were sprayed with the four washes.

Spray Fluids Employed.

The following four spray fluids were used, made up to the formulæ given below.

A. AMMONIUM POLYSULPHIDE AND SOFT SOAP.

Ammonium polysulphide (1919 formula)	4 pints.
Soft Soap	5 lbs.
Water, to make up to	100 gallons.

B. PROPRIETARY SODA-SULPHUR COMPOUND AND SOFT SOAP.

Soda-sulphur compound	10 pints.
Soft soap	5 lbs.
Water to make up to	100 gallons.

C. WASHING SODA AND SOFT SOAP.

Washing soda	19 lbs.
Soft soap	11 lbs.
Water	100 gallons

D. BURGUNDY MIXTURE.

Copper Sulphate	15 lbs.
Washing soda	34 lbs.
Water	100 gallons

Application of Spray Fluids.

The washes were applied by means of a hand pumped " Rapid " spraying machine, working at a pressure of 60-80 lbs., the nozzle used producing a medium-fine misty spray. Particular care was taken to spray the lower parts of the bushes and, as far as possible, the under sides of the leaves. To ensure uniform treatment all spraying was done personally by the writer.

The sprays (A), (B) and C) were applied on April 28th, immediately after the setting of the flowers, at which time no sign of the disease was visible on any part of the bushes.

The second application of (A), (B) and (C) and the first application of (D) took place on June 5th. At this time the mildew had appeared on the control plot and on the plot (D).

Results.

The fruit from the various plots was picked on June 23-25th., the fruit from each plot being picked separately. It was sorted into two grades—clean and mildewed berries—which were then weighed. The fruit from the control plot was treated similarly.

The following table gives the weight of clean and mildewed berries from each plot.

Spray used.	Clean Fruit. lbs.	Mildewed Fruit. lbs.	Percentage Mildewed Fruit by weight.
A. Ammonium polysulphide and soft soap.	90	4	4.2
B. Soda-sulphur compound and soft soap.	132	3	2.2
C. Washing soda and soft soap.	92	4¼	4.5
D. Burgundy Mixture.	94	27	22.3
Control. No spray.	36	28	43.7

Remarks.

From the above table it will be seen that the sprays (A), (B) and (C) have all given very good results, but it is not considered that the trial was on a sufficiently large scale to obtain figures so free from experimental error as to permit of an accurate determination of the *relative* efficacy of the three sprays. Further trials

are necessary before definite conclusions can be arrived at. The time of the first application of the sprays, *i.e.*, as soon as the flowers had set, is considered important. At this date (April 28th) no sign of the disease could be seen, yet it would appear that small infection centres, originating from the winter spores, must have been present though invisible to the naked eye, since the control bushes were heavily infected before the second application was made (June 5th). In the case of plot (D) in which the first application was not made until after the mildew had become visible, only a comparatively poor control was obtained. It is essential, therefore, that fruit growers should not wait until the disease can be seen before commencing to spray.

It is obvious that the spray (D), Burgundy Mixture, was applied too late to check the disease effectively ; it is possible that this would be an efficient spray if applied three or four weeks earlier. When applied after the berries are half grown, the latter are rendered unsaleable owing to the visible deposit on their surfaces.

The spray (C), Washing Soda and Soft Soap, was tested because this, if always efficient, would be a valuable and economical wash for use with certain varieties which are damaged by the sulphur-containing spray-fluids. Further, it is readily made up by small growers and private gardeners, the ingredients being common household commodities. Trials made with Soda in Russia several years ago also gave promising results, and it was first used in this country by Mr. Lansdell, late of the Worcestershire Horticultural Department, from whom the formula was obtained.

No spray damage was observed on any of the plots, and the same holds good for the variety " Keepsake," which was sprayed with similar materials at another centre.

The plots were again inspected on October 7th, when it was found that on the control plot and on plot (D) many of the tips were brown with mildew, whereas on plots (A), (B) and (C) they still remained clean.

In conclusion, the writer is greatly indebted to Mr. Frank May, of Cheltenham, on whose plantations the trial was carried out, for giving every facility and for supplying labour and machinery ; and also to Mr. G. H. Hollingworth, Agricultural Organiser for Gloucestershire, for his valuable help in selecting a suitable plantation.

A NOTE ON THE LEAF SPOT DISEASE OF BLACK CURRANTS.

By H. R. Briton-Jones.

This disease, which is caused by the fungus Pseudopeziza ribis (Klebhahn), occurs to some extent every year, but it is only occasionally that it becomes so bad as to cause serious damage over any large area of the country. In the report of the fungus diseases of crops 1920-1921 published by The Ministry of Agriculture and Fisheries it is stated that the disease was " very bad on Seabrook's Black (Sussex, 1921). In Worcestershire and Hampshire especially on Boskoop Giant (1920)". Last year, 1924, the disease was very prevalent throughout the western counties. It will be recalled that the summer of 1924 was one of the wettest on record and there was undoubtedly a connection between the amount of rainfall and the amount of disease. In spite of this, however, it was observed that bushes in some plantations were almost free from disease whilst in other plantations bushes of the same variety were entirely defoliated and the currants shrivelled up early in the season. This observation was made in several instances in different localities. As already stated defoliation due to the disease took place in some cases so early in the season that it was followed by a shrivelling of the currants resulting in an almost complete loss of crop. The damage to the crop was not confined to last year's crop of fruit because early defoliation meant that there was, at the end of the growing season, a much lower percentage of fruit buds which would produce fruit in 1925.

The incidence of the disease this year, (1925), was, generally speaking, considerably less than in 1924. On the other hand the disease caused great damage in some plantations, so that although heavy rainfall during the summer months is conducive to an increase in the amount of the disease, it is evident from what has been said that there is another factor of paramount importance in connection with Leaf Spot disease. The general impression obtained as the result of the above observations was that bushes which were making a fair amount of new and strong growth were not affected to any serious extent whereas those which were not making new growth suffered very seriously from the disease.

The variety of black currant which suffered most heavily from the disease in both 1924 and 1925 was Baldwin. Other varieties, such as Seabrook's Black, Boskoop Giant, etc., were also attacked, but to a much less extent than Baldwin. This was the case in plantations of a collection of varieties where manurial and other treatments had been the same throughout.

The above points were brought out very clearly this year in a plot of a collection of black currants at Long Ashton. The plot consisted of 5 rows each of Edina, Boskoop Giant, Seabrook's Black, and 6 rows of Baldwin. The manurial treatment had been liberal and uniform throughout. The first four bushes in each row were given a hard pruning in the winter; the second four were given a light pruning only, and so on alternately in fours throughout the rows. The hard-pruned Baldwins, light-pruned reverted Baldwin, and light-pruned Seabrook's Blacks were not seriously affected with Leaf Spot, whereas the light-pruned Baldwins were badly attacked and became defoliated to an appreciable extent. By hard pruning a Baldwin a certain proportion of the fruiting wood is removed so that the crop is reduced to some extent in the season following the operation. On the other hand, the bush produces a fair amount of new wood which will bear fruit in the following season. In other words the vigour of the bush is not reduced by overcropping. The light-pruned reverted Baldwin bushes, although they did not produce as much new growth as the hard-pruned Baldwins, did not contract the disease to any serious extent, because being reverted they did not carry a crop. Thus the bushes maintained their vigour. The light-pruned Seabrook's Blacks carried a crop and produced new growth, but did not contract the disease seriously. This may be due to the fact that it is not such a heavy bearer as Baldwin and at the same time is a much stronger grower. The light-pruned Baldwins, being weak growers as compared with other varieties and carrying a heavy crop, became so exhausted that they contracted the disease to a serious extent.

The difference in the amount of disease in the hard-pruned Baldwins and the light-pruned Baldwins suggests a ready and simple means of controlling the Leaf Spot disease. Any operation which tends to increase the vigour of the bush will also be reflected in a reduction in the amount of disease.

In the United States (1) it is recommended to spray with Bordeaux mixture 5—5—50, or lime-sulphur solution at a strength of 1 in 40 or 1 in 50, the first application to be given when the leaves are unfolding. The fungicide is to be applied at intervals of ten to twenty days until five or six sprayings have been made. The number of sprayings depends on weather conditions. Fewer

applications can be given in dry weather and in a wet season more frequent applications are necessary. It is also suggested that, since the fungus is said to hibernate on fallen leaves, these should be destroyed, although it is added that in all cases there would be enough leaves to act as an abundant source of trouble.

The above measures might be successful as means of control in this country, but obviously under present conditions of labour, etc., in England half a dozen or mores prayings of black currants is out of the question. A further point in regard to spraying is that the above mentioned fungicides leave a deposit not only on the leaves but on the currants as well. It is therefore quite conceivable that after the last application of the spray a spell of dry weather might set in and the currants when ripe would still be coated with a copper-lime or sulphur deposit. Ripe black currants are soft and small and it is evident that it would be almost impossible satisfactorily to clean them. It is equally impracticable to suggest the burning of fallen leaves. Large numbers of leaves become lodged, in the bush stools and they cannot be buried by normal implements of cultivation. The only other alternative is to collect these leaves by hand. In the case of some diseases the sources of infection can be reduced by hygienic methods of cultivation, but in the present case as in several other diseases the presence of the source of infection must be accepted as an unpleasant fact.

Whether hard-pruning and liberal manuring will serve as a completely satisfactory means of dealing with the disease remains to be proved by future work. It has, however, been already shown that more can be done in this manner to satisfy the practical man than by any other known means. It is possible that an application of a fungicide to leaves after the crop is picked will be necessary, but for the moment this is doubtful since by that time most of the damage is already done.

The above is an example of the possibility of disease control not by making a direct attack on the parasite but by taking measures to bring about conditions within the host plant which render it less liable to disease.

A point of some importance to the plant breeder is brought out by the facts already stated. It would seem at first that Baldwin black currant bushes are more highly susceptible to this disease in a genetical sense than other varieties. On closer examination, however, it will be found that this is by no means the case. The light-pruned reverted bush was not more affected than the light-pruned Seabrook's Black. Nor was the Baldwin hard-pruned more affected than the hard-pruned bushes of other varieties. Provided the Baldwin is given pruning and manurial treatment to keep up its

vigour it is not more affected than others. The reason why it is actually more often and more badly affected is due to the fact that it exhausts itself by heavy cropping and is a weak grower. The hereditary factor, therefore, is not one of susceptibility to disease but one of heavy cropping and weak growth. Without a critical study of the condition of plants it is unsafe to state that any one variety is more susceptible to disease than another.

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WHITE ROT DISEASE OF ONIONS—IMMUNITY TRIALS.

By R. M. Nattrass.

At the Advisory Conference held in December, 1924, Advisors were asked to assist Mr. E. Holmes Smith in the testing of varieties of onions immune to the White Root Rot disease, *Sclerotium cepivorum.*

Through the kindness of Mrs. A. Fox, of Brislington House, Bristol, permission was obtained to sow the different varieties on a plot of land which was badly contaminated with the White Rot disease.

The seed for this test was supplied by Mr. E. Holmes Smith. Two rows, eight yards long, were sown of each variety. Owing to the exceptionally dry season, only the very susceptible varieties were slightly attacked. The seed was sown on March 16th, 1925, and the crop was lifted on September 16th, 1925.

The list below gives the variety and the number of diseased bulbs in each row.

No. of Row.	Variety.	Susceptibility	No. of diseased bulbs.
1	Cranston's Excelsior No. 4	Very susceptible	2
2	Magnum Bonum „ 1	Immune	0
3	Cranston's Excelsior „ 8	Very susceptible	1
4	Selected Coconut „ 3	Immune	0
5	A.1. „ 7	Slightly susceptible	0
6	Selected Red „ 5	Immune	0
7	Cranston's Excelsior „ 4	Very susceptible	2
8	Ailsa Craig „ 6	Very susceptible	0
9	Magnum Bonum „ 1	Immune	0
10	Cranston's Excelsior „ 8	Very susceptible	0
11	Strasburg „ 2	Very susceptible	1
12	Ailsa Craig „ 6	Very susceptible	1
13	Selected Coconut „ 3	Immune	0
14	Strasburg „ 2	Very susceptible	2
15	Selected Red „ 5	Immune	0
16	A.1. „ 7	Slightly susceptible	0

REPORT ON SEED "PICKLING" INVESTIGATION.

By R. M. Nattrass.

In November, 1924, a request was received from the Ministry that the enquiry as to the effect of pickling on the germination of seed wheat should be continued. The Advisory Mycologist was asked to collect from farmers, samples of seed wheat, before and after treatment with different pickles or with the same "pickles" at different rates. The treated samples were all drawn from bulk which had been actually pickled on the farm.

The samples were obtained from the following counties :-

Gloucestershire	6 samples
Wiltshire	5 „
Somerset	1 sample

The germination of the treated and untreated samples was tested by the Seed Testing Station of the National Institute of Agricultural Botany.

The table below gives, under various heads, particulars of the samples tested, together with germination data. The extreme right-hand column gives the percentage difference in germination between the treated and untreated samples. The information is set out in the order in which the treatment has affected the germination.

Germination of Seed Wheat.

No.	Treatment	Variety.	Germination % Days Count. 5 days.	7 Days.	Final.	
1.	1 lb. of copper sulphate per sack dissolved in enough water to damp the whole.	Little Joss.	Untreated	61	65 in 14 days 67	+ 6%
			Treated	65	69 in 15 days 73	
2.	"Corvusine."	Red Standard	Untreated	69	83 98	+ 0%
			Treated	63	84 in 14 days 92	
3.	"Formalin"—1 tablespoonful to 1 gallon of water. 1 gallon of solution to 1 sack of wheat.	Snow-drop.	Untreated	78	94 95	+ 0%
			Treated	74	92 95	
4.	"Formalin"—1 oz. to 3 gallons of water. 2 gallons of solution to one sack of wheat.	Little Joss.	Untreated	78	97 98	— 1%
			Treated	75	95 97	
5.	"Formalin"—1 tablespoonful to 2 gallons of water. 2 gallons of solution to 1 sack of wheat.	"Square-heads" Master	Untreated	80	97 97	— 2%
			Treated	76	93 95	
6.	1lb. of copper sulphate to 1 gallon of water—1 gallon of solution to 6 bushels of wheat.	Red Standard	Untreated	80	85 87	— 3%
			Treated	70	79 84	
7.	Tar-lime—the seed was treated with a small quantity of tar and then with lime to prevent the seed sticking.	Red Standard.	Untreated	40	80 96	— 6%
			Treated	55	80 90	
8.	¾ lb. copper sulphate to 1 gallon of water—1 gallon of solution to 1 sack of wheat.	"Square-heads" Success.	Untreated	86	96 98	— 9%
			Treated	70	83 89	
9.	"Corvusine"—1 gallon to 12 bushels of wheat.		Untreated	88	95 96	— 10%
			Treated	49	71 86	
10.	1 lb. of copper sulphate to 1 gallon of water--1 gallon of solution to 1 sack of wheat. Lime was mixed with the damp seed just before it dried.	Victor.	Untreated	88	96 98	— 10%
			Treated	83	86 88	
11.	1 lb. of copper sulphate to 1 gallon of water—1 gallon of solution to 1 sack of wheat, followed by Gregory's Gottem.		Untreated	66	91 93	— 21%
			Treated	13	37 55 in 18 days 72	

Remarks.

It will be seen that with the exception of samples 1, 2, and 3, the treatment in each case had a depressing effect on the germination—more so in the case of Copper Sulphate than in the case of "Formalin."

No. 1. Copper Sulphate caused an increase of 6% in the germination of an exceptionally poor sample.

The "Formalin" treatment only had a small effect on the germination of from 0 to —2% (Samples 3, 4 and 5).

The effect of Copper Sulphate varied from —3% to —21%, but in no case was more than 1 gallon of the solution used to 1 sack of wheat. Had 2 gallons per sack been used, which is considered necessary thoroughly to wet the whole, the depressing effect would have been much greater. In the case of formalin with 2 gallons of solution per sack, the effect is only very slight.

The fields were visited at harvest time, but no sign of bunt could be seen on any of the crops.

It is hoped that the standard method of treatment of seed wheat with formalin will become general.

THE PECTIN CONTENT OF NORMAL AND "SILVERED" APPLE LEAVES.*

By Frank Tutin.

During a recent investigation the observation was made that the young bark of the apple contained a very appreciable amount of pectin. The variety of apple examined was Bramley's Seedling. The bark, after mincing, was thoroughly extracted with boiling alcohol and then, after drying, with boiling water. The aqueous extracts, after concentration under diminished pressure, yielded, on precipitation with alcohol, a product which appeared to be essentially identical with the pectin obtained from apple fruit, with the exception that it contained a very small amount of starch. On treatment with alkali it gave methyl alcohol and acetone and on treating its aqueous solution with the enzyme, pectase, a good gel was soon formed, although not quite so quickly as was the case when employing pectin obtained from the fruit.

This discovery of pectin in the young bark suggested that apple leaves might also contain this substance. A quantity of apple leaves was therefore examined for pectin in a manner similar to that employed when investigating the bark. A good yield of pectin was then obtained, but it was not quite so pure as that derived from the bark since it contained rather more starch and did not gel so quickly with pectase.

It was observed, however, that while the leaf fragments, which had been previously exhausted with boiling alcohol, were being deprived of pectin by means of boiling water they developed a silvery appearance precisely resembling that shown by leaves affected by the well-known "Silver Leaf" disease. The possibility of "Silver Leaf" being associated with pectin deficiency was therefore investigated.

As is well known, "Silver Leaf" is a disease particularly affecting plum trees, but other trees, including the apple, may also become infected by it. Leaves of the last mentioned were chosen for the present investigation since material particularly well adapted for this purpose was readily available, and, moreover, the results so obtained would be comparable with the observations already made, which are recorded above.

* Reprinted from the Biochemical Journal, 1925, xix, 414.

The tree chosen was an espalier apple of the " Keswick Codlin " variety, the upper branch on one side of which only was affected with " Silver Leaf " disease. On the morning of July 22nd 40 average leaves, without stalks, were collected from near the end of the diseased branch, and a like number from a similar position on the corresponding branch on the other side of the tree, which was perfectly normal. After weighing, each sample of leaves was cut into narrow strips and thrown into boiling alcohol. After boiling for 15 minutes the extractions were completed in a Soxhlet apparatus with fresh quantities of alcohol. After drying and weighing the material which had been exhausted with alcohol, each sample was extracted a number of times by boiling with large volumes of distilled water for the removal of the pectin. The latter, after concentration of the extracts under diminished pressure, was precipitated by means of alcohol, collected, dried and weighed. The results obtained are given below :

	Original weight of 40 leaves	Weight of alcohol-extracted marc	Weight of pectin	% of pectin in alcohol extracted marc.
	g.	g.	g.	
Normal leaves	35.15	7.70	1.30	16.89
" Silvered " leaves	29.70	6.50	0.97	14.90

It is thus seen that the leaves affected by " Silver Leaf " disease contain an appreciably smaller amount of pectin than do the normal leaves. Moreover, the yield of pectin calculated on the weight of the fresh, normal leaves (3.7%) seems surprisingly large when compared with the proportion of this substance found by the present author [1921, 1923] to occur in the peel and pulp of the fresh fruit, namely, 2.6 and 1.3% respectively. The pectin obtained from the leaves, however, is not so pure as that prepared from the fruit, but the amount of impurity present certainly does not seem sufficient to account for the increased yield obtained from the leaves as compared with that from the fruit.

Although the presence of pectin in apple leaves does not appear previously to have been recorded, it is known that they contain the enzyme, pectase. Thus, if fresh apple leaves be well pounded with a little water and the resulting mass strongly pressed, the juice so obtained, if added to a solution of pectin in the presence of chalk, causes the formation of a solid gel of calcium pectate. The expressed juice of the leaves appears, however, to contain little, if any, pectin.

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CHEMICAL INVESTIGATIONS OF FRUITS AND THEIR PRODUCTS.

I.—Apple Juice as a Source of Sorbitol.*

By Frank Tutin.

The material generally employed as a source of the hexahydric alcohol, sorbitol, namely, the berries of the Mountain Ash (*Pyrus aucuparia*, Gaertn.), is not always readily obtainable, even at the appropriate season of the year. Moreover, in the author's experience it is by no means always an easy matter to isolate sorbitol from this source. During an investigation on the constituents of apples it has been found that they contain an appreciable proportion of sorbitol and, since apples are always obtainable and the isolation of sorbitol from them may easily be accomplished, it would appear that this fruit affords the most convenient source for the compound in question. The method employed for the isolation of sorbitol from apples is briefly as follows.

The apple juice was first concentrated under diminished pressure to about one-third its volume. A slight excess of basic lead acetate solution was then added and the resulting precipitate removed by filtration. The filtrate, after being deprived of lead by means of hydrogen sulphide, and the excess of the latter removed, was fermented with yeast in an incubator until the evolution of carbon dioxide has apparently ceased.[1] The mixture was then considerably concentrated under diminished pressure and again treated with basic lead acetate as previously described, after which the filtrate, which was now much diminished in volume, was again fermented, as it was found that an appreciable amount of sugar always remained after the first fermentation was apparently complete. A final clearing with lead was then employed and the filtrate, after being deprived of lead, was evaporated as far as possible under diminished pressure.

The gum-like residue so obtained was then covered with an excess of acetic anhydride, some pyridine added as a catalyst, and the mixture cautiously warmed on a water-bath, when acetylation occurred rapidly after the temperature had been somewhat raised.

* Reprinted from the Biochemical Journal, 1925, xix, 416.

1 The addition of some "yeast water" and a little ammonium phosphate greatly accelerates the fermentation.

When the first vigorous reaction was over the mixture was kept boiling for 1 hour to ensure complete acetylation, after which it was cooled to about 50° and water cautiously added to decompose the excess of acetic anhydride present. Finally, a considerable excess of water was added and the mixture extracted several times with ether. The combined ethereal extracts were washed several times with water and then extracted successively with aqueous sodium carbonate and sodium hydroxide, after which they were again washed with water, and dried. During the extraction with alkalis and the final washing with water appreciable amounts of brown resinous products were removed. On evaporating nearly all of the solvent from the purified ethereal extract a pale yellow residue was obtained, which soon crystallised in aggregates of hard, colourless prisms. The latter were deprived of adhering, pale yellow, viscid material by draining on a porous tile in an atmosphere saturated with ether. After recrystallisation from ethyl acetate colourless prisms melting sharply at 99° were obtained, and were identified as hexa-acetylsorbitol. In *Richter's Lexicon* the latter compound is described as a syrup, on the authority of Vincent and Delachanal [1889] but Thorpe [1912] gives the melting point as 99°, in accordance with the value found by the present author. Hexa-acetylsorbitol is readily soluble in alcohol, moderately so in ethyl acetate and rather sparingly soluble in ether. It dissolves slightly in boiling water.

For the regeneration of sorbitol 2% aqueous sulphuric acid was added to a quantity of the above-described hexa-acetyl derivative and the mixture boiled in a flask attached to a reflux condenser until solution was complete. Steam was then passed through the mixture until acetic acid was no longer removed, after which the sulphuric acid was exactly precipitated by the addition of aqueous baryta, and the filtrate from the barium sulphate evaporated to dryness under diminished pressure. The residue so obtained was dissolved in alcohol from which it slowly separated in colourless crystals which, after drying, melted at 110°, and were identified as *d*-sorbitol.

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CHEMICAL INVESTIGATIONS OF FRUITS AND THEIR PRODUCTS.

II.—The Fate of Sugar during "Cider Sickness."

By Frank Tutin.

The disease known as "Cider Sickness" or "Second Fermentation" is, amongst all the disorders to which cider is liable, the most dreaded by cider makers in this country. It has been much studied by Barker [1906, 1907, 1911, 1912, 1, 2] who has shown that it is caused by a specific organism which attacks chiefly sweet ciders of low acidity when the temperature becomes somewhat raised. It causes a very rapid disappearance of the sugar, together with the formation of alcohol, acetaldhyde, formaldehyde, carbon dioxide, and hydrogen. He also obtained conclusive evidence that part of the sugar was converted into some non-reducing substance, which could not then be isolated nor its nature ascertained.

Since the acetylation method described in the preceding paper had proved so convenient for the isolation of sorbitol from apple juice it was decided to employ it for the investigation of the non-reducing substances present in "sick" cider. A quantity of the latter in which the "sickness" fermentation had been allowed to proceed to the ultimate limit was therefore concentrated under diminished pressure, purified by means of basic lead acetate, and the solids contained in the filtrate acetylated in the manner described in the foregoing paper. The resulting acetylated material, after purification in the manner employed when isolating the hexa-acetylsorbitol (preceding paper, p. 258), was obtained in noticeably greater yield than the corresponding product from the fresh juice. It could not, however, be induced to crystallise either by long keeping or by inoculating with a crystal of hexa-acetylsorbitol. When, however, a small particle of hexa-acetyl-*d*-mannitol was introduced crystallisation commenced and, during the course of some weeks, gradually spread throughout the viscid mass, but the proportion of crystalline material deposited was not large. The very viscid mixture was then brought on to a porous tile and allowed to drain

* Reprinted from the Biochemical Journal, 1925, xix, 418.

in an atmosphere saturated with alcohol vapour. The white solid so obtained, after one crystallisation from alcohol, melted at 123° and was identified as hexa-acetyl-*d*-mannitol. A small amount of hexa-acetylsorbitol was subsequently isolated from the viscid material which had been absorbed by the tile.

Since no mannitol could be detected in apple juice after fermentation with yeast only, it appears evident that fermentation by the "sickness" bacillus results in the reduction of a portion of the sugar present to mannitol, a change which is known to be brought about by certain other bacteria and which is in harmony with the observation of Barker that hydrogen is evolved during "sickness" fermentation.

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CIDER-MAKING TRIALS FOR THE SEASON 1924-25.

By O. Grove.

The 1924 crop of English cider apples was very small. This is perhaps best illustrated by the fact that according to French official figures, over 24,000 tons of French cider apples were exported to this country during the season for cider making.

Although the average specific gravity of all the juices expressed at Long Ashton was rather on the low side, namely, 1.0483, the ciders were, upon the whole, of good quality. On the Tasting Day, in May, 1925, they were judged as one of the best collections ever exhibited.

Washing of Apples.

The fact that for the first time all the apples were washed before being milled had, without doubt, something to do with the good flavour of the ciders made. Hitherto it had been the practice at the Institute only to wash apples that did not arrive in a clean condition, washing being considered unnecessary in other cases. It was, therefore, something of a revelation to see the large amount of foreign matter collected in the bottom of the washing tank after a day's washing of apparently clean apples, an amount more than sufficient to convince the most sceptical of the desirability of washing. From another point of view the washing proved very beneficial; the filtration of the ciders was carried out with much more ease than usual. This was a not unexpected result after seeing the amount of debris washed away before pressing and thus prevented from being carried with the juice to block up the filtering material.

The washing was carried out by a very simple contrivance. The washing vessel was a wooden vat of the following dimensions :— 6 feet long by 3 feet wide and $1\frac{1}{2}$ feet deep. This was kept filled with running water. This vessel was separated lengthwise into two compartments for about half its length by a wooden partition, on the one side of which the apples were pulled up a sloping board to an elevator by means of a wooden rake (a piece of perforated wood with a long handle). On the other side of the partition the apples were fed into the trough, so they had to travel through the

water in the container along one side and around the partition before reaching the sloping board aforementioned. A sprinkler was arranged above the place where the apples passed from this to the elevator, so that they were rinsed with clean water just before going into the mill. The level of the water in the vat was kept constant by means of an overflow placed one foot above the bottom. Besides washing the apples this arrangement also had the advantage that it eliminated all badly decayed apples, since, being heavier than water, they sank to the bottom of the vat, whereas the sound apples floated. Stones were eliminated in the same way. Such a washing arrangement can easily be made at home by a farmer or cider maker at very little cost.

Pasteurisation Trials.

As will be seen in the list of ciders given below, some of the juices were pasteurised immediately after pressing and subsequently fermented with a pure yeast. The pasteurisation was carried out by means of a new type of pasteurising apparatus of French design and manufacture. This apparatus consists of two sections, the pre-heater and the pasteuriser proper. The pre-heater, into which the juice is first passed by means of a pump or by gravity, consists of a set of cylinders made of tinned copper, uniform in height but of different diameters. These cylinders are fitted one into the other in such a way that there is a space of about one-third of an inch between the wall of one cylinder and the wall of the next. The whole system forms a set of covered, narrow, cylindrical canals, about 8 inches high, through which the juice flows. The cold juice entering and the warm juice discharged from the pasteuriser pass through an alternating set of canals, so that the cold juice cools the warm, which at the same time raises the temperature of the former. By this arrangement of temperature exchange, the pasteurised juice leaves the apparatus cold, whereas the cold juice has already been partly heated before it reaches the pasteuriser. From this pre-heater the juice passes into the pasteuriser, which consists of a coil of tinned copper-tubing, about 2 inches in diameter, through which the juice flows. This coil is placed in a closed metal container filled with water, which is heated by a small steam pipe. Before starting the pasteurisation the whole apparatus is sterilised by blowing steam through it, and the delivery tube through which the pasteurised juice flows to the receiving cask, the latter also being disinfected and steamed immediately before it receives the juice.

The process is begun by heating the water in the container to boiling point, and the juice is then pumped slowly through the whole apparatus. At the point where the juice leaves the pasteur-

iser and enters the temperature-exchanger, a thermometer is situated, this being the point where the highest temperature is reached. By regulating the steam supply and the rate of pumping, the thermometer can be maintained at a temperature of 70° C. (158° Fah.), this being the required degree for pasteurisation. The apparatus used at the Institute pasteurises about 100 gallons per hour. Owing to the ingenious temperature-exchanger very little steam is needed to keep the thermometer at 70° C.

By this treatment all the micro-organisms in the juice are stated to be killed. This claim was repeatedly tested by taking samples at intervals and placing them in an incubator at 25° C. ; no development of micro-organisms took place. Hence the efficiency of pasteurisation by this machine can be accepted as proved. After pasteurisation of the juice it was inoculated with a culture of yeast, which had previously been grown in a Pasteur flask, using as medium one litre of sterilised apple juice. Such a culture was found quite sufficient to start the fermentation in a cask containing 100-116 gallons of juice.

In considering the value of this process for cider making, there are both advantages and disadvantages which have to be taken into account. In cider making as it is generally carried out, the juice is put into a cask or vat and left to ferment spontaneously, the fermentation being carried out by the yeasts present in the juice. In this case, there is one factor, namely, the juice, about which the essential points can be quickly ascertained by analysis. Besides this, there are a larger or smaller number of uncertain factors, namely, the numerous and diverse micro-organisms in the juice, some useful for our purpose, some indifferent, and some such as acetic bacteria, bacteria causing ropiness, cider-sickness, etc., very harmful.

If all the micro-organisms in the juice are killed by pasteurisation and the fermentation is effected with a selected type of yeast, there are then two known factors to work with instead of one known and a great number of unknown ones. It goes without saying, that this is a great advantage. As regards the type of yeast to use, there is a large selection of pure yeast types which have been isolated from cider, various wines and other fermented beverages to choose from, and it is only a question of experiments to select the type that suits the purpose best. The type of yeast wanted in cider is one that gives a slow fermentation, a good and rapid clearing of the juice, settles down with a hard deposit, and, last, but not least, that communicates a good flavour to the cider.

During the season several yeasts have been tried at the Institute, and it has been found that the Institute yeast No. 6 gave the best results. This yeast was isolated from a Kingston Black cider in 1913. It gives a good clarification of the juice—very superior to the clearing in the control samples fermented naturally ; it settles down well in the bottles ; and it was judged by experts on the Tasting Day to yield the best flavoured cider.

During the 1925-26 season a number of new yeasts are being experimented with. It is clear that when the best type of yeast has been selected and juices always fermented with it, an important step towards a more standardised product will have been taken.

In all cases in the 1924-25 trials where the juices were pasteurised, the fermentation proceeded very slowly, compared with the naturally fermented control samples. This can be seen in Table I. appended.

TABLE I.

Rates of Fermentation of Pasteurised Juices as Compared with the Unpasteurised Control Sample.

	Original Specific Gravity	Specific gravity after: 1	2	3	4	5	6	7	8	9	10	11	12 weeks
35 (control, fermented naturally)	1.046	1.041	1.035	1.028	1.025								
36(pasteurised,fermented with yeast No. 6)	1.046	1.044	1.039	1.037	1.034	1.031	1.029	1.026					
37 (,, fermented with yeast No. 37)	1.046	1.044	1.040	1.037	1.034	1.031	1.030.	1.027					
43 (control, fermented naturally)	1.046	1.042	1.040	1.034	1.030	1.028	1.024						
44(pasteurised,fermented with yeast No. 6)	1.046	1.042	1.037	1.037	1.036	1.035	1.035	1.034	1.033	1.032	1.030	1.028	1.026
45 (,, fermented with yeast No. 9)	1.046	1.043	1.039	1.038	1.038	1.037	1.036	1.035	1.033	1.032	1.031	1.029	1.026
46 (,, fermented with yeast No. 37)	1.046	1.043	1.038	1.038	1.038	1.037	1.037	1.035	1.034	1.032	1.030	1.027	1.025

It will be seen that in the first lot the control cask, No. 35, fermented down to a specific gravity of 1.025 in four weeks, whereas No. 36 and No. 37 took seven weeks to ferment down to a specific gravity of 1.026 and 1.027 respectively. In the second lot the control, No. 43, reached a specific gravity of 1.024 in six weeks, but the pasteurised samples took twelve weeks to ferment down to specific gravities of 1.026 in the case of Nos. 44 and 45 and to 1.025 in the case of No. 46.

The time taken for the fermentation to reach a certain specific gravity was thus, as a rule, four to six weeks more in the case of the pasteurised samples than in the case of the naturally fermented control. This is obviously a great advantage, as it allows racking and filtering to be spread over a much longer time, so that the usual rush to get these operations carried out in time is obviated. The reasons for this slowing down of the rate of fermentation are several, probably the most important being that some of the nitrogenous material, which serves as a food for the yeast, is coagulated by the heat and made less available for the yeast.

The destroying of such harmful organisms as acetic bacteria, ropiness and sickness bacteria, etc., is also clearly a great advantage. In the case of acetic bacteria it is true that they are so common, that an infection from the air after the fermentation is possible, but the untold millions of them always present in the fresh juice and ready for action as soon as the fermentation slows down, are made harmless by pasteurisation. As regards the special disease organisms of cider, it is most unlikely that infections from the air occur, so the two common and very serious disorders in cider, sickness and ropiness, are eliminated by the pasteurisation process.

The possible disadvantages of the pasteurisation are two: (*a*) adverse influence of the heating of the juice upon the flavour of the cider; and (*b*) the cost of the treatment. As regards the action on the flavour, if the juice is heated under the conditions described above, it can be claimed that there is no conspicuous effect. Many comparisons between the flavour of the freshly pasteurised juices and the ciders made from them and the unpasteurised juices and the control ciders have been made, and it has not been possible to detect any "cooked" flavour. The only difference so far noted is that the pasteurised material lacks a certain freshness of flavour which is characteristic of the untreated liquor. This point is difficult to detect unless the ciders are compared side by side and is normally missed by the uninitiated sampler. As regards the cost, exact figures cannot be given, but it can be said to be very low, as very little steam is used because of the pre-heating arrangement described above.

Single Variety Trials.

With regard to the single varieties described in the appended list, No. 1 was an unnamed apple from Kings Weston, Somerset, which has not previously been tried for cider. The trees are good growers and croppers and, although the juice was low in specific gravity, the cider was good, with a clean sharp flavour, very useful for blending with lower acid varieties. Nos. 2 and 3 were good samples of these two well known varieties. The Kingston Blacks, Nos. 4-9 were very good samples, Nos. 7, 8 and 9 being the best; the latter particularly was an excellent cider. No 10 was made from apples grown at the Research Station; they produced a very useful sweet cider. No. 11 was a very good sample of this well known Devon variety.

The next five on the list, Nos. 12-16, were made from French apples imported from Normandy. They were good ciders with a remarkable soft and pleasant flavour and similar in character. No. 12, Bedan, was the best. This apple is one of the best known cider varieties in France. All the samples of these five French varieties kept well in bottle until the beginning of the summer, when cider-sickness started in Nos. 14, 15 and 16. This was more or less expected, as they all belong to a class of apples with low acidity juices, which are very liable to be attacked by this disorder. Besides the single variety samples, several lots of mixed French apples from the Vallee d'Auge in Normandy were made up during the season. Typical for all the juices made from these apples was a lower acidity (0.16 to 0.30 per cent. of the malic acid) than usually present in English mixed apples and in many cases a high tannin content. The specific gravities of the juices were rather low, about 1.046. Although the ciders made from mixed French apples were very fair in flavour, they lacked briskness because of the low acidity and were in many cases too bitter, owing to the high tannin contents. The ciders showed a tendency to darkening of the colour when exposed to the air for a short time. The best results were obtained when these ciders were blended with English ciders made from sharper varieties.

No. 17, Mansell Seedling, gave a juice with a low specific gravity; the cider was very fair without much character. Nos. 18, 19 and 20 were quite good samples of bitter-sweet ciders; the Royal Wilding was the best.

Of the culinary varieties No. 23 was the pick of the Worcester Pearmains and No. 27 the best of the Bramley Seedlings. Both of these were produced from trees growing in an orchard in a very low state of culture; consequently, the juices gave a very desirable

slow rate of fermentation, due to low contents of nitrogen. As a rule the juices from culinary apples have a relatively high content of nitrogen, with a rapid rate of fermentation, which makes it difficult to make the popular sweet type of cider from them.

The perries Nos. 28-30 were of fair quality. No. 29 was specially good for the variety, which is not one of the best perry pears.

The four lots of mixed apples, Nos. 31-34, all produced very acceptable ciders. No. 32 had a rather high content of tannin and was consequently rather bitter in flavour.

As regards the ciders made from pasteurised juices, Nos. 35, 36 and 37 did not show great differences in character. No. 36, fermented with pure yeast No. 6, originally isolated from a Kingston Black cider, had the best flavour. No. 37 had a wine-like aroma and was fermented with yeast No. 37, isolated from a Rhenish wine. No. 39 was judged to be superior to the control ; it was fermented with yeast No. 9, isolated from a Sweet Alford cider. In the next two lots, Nos. 40-42 and Nos. 43-46, the samples fermented with yeast No. 6 were decidedly superior to the other samples. This was especially pronounced in the case of No. 44, which was well above the control, No 43, and better than the samples No. 45 and No. 46.

TABLE II.

Analytical and other Data of the 1924-25 Ciders.

No.	Name of Variety.	District where grown.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent	Rate of fermentation at 25° C.	Date of Filtering.	Specific Gravity May, 1925
	APPLES—								
	SHARP VARIETIES—								
1	Red Apple	Kingweston, Som.	2/12/24	1.043	0.80	0.19	6.4	10/1/25	1.013
2	Dymock Red	Dymock, Glos.	20/10/24	1.044	0.59	0.27	3.4	24/11/24	1.027
3	Fox Whelp	Credenhill, Her.	7/11/24	1.054	0.90	0.35	2.2	15/12/24	1.035
4	Kingston Black	Dymock, Glos.	6/11/24	1.058	0.72	0.22	2.0	29/12/24	1.025
5	,, ,,	Kingweston, Som.	20/10/24	1.058	0.75	0.24	4.7	8/12/24	1.026
6	,, ,,	Moorhampton, Her.	20/11/24	1.048	0.58	0.16	3.1	5/1/25	1.026
7	,, ,,	Taunton, Som.	6/11/24	1.058	0.71	0.21	2.0	10/1/25	1.027
8	,, ,,	Credenhill, Her.	6/11/24	1.055	0.64	0.18	1.7	19/1/25	1.030
9	,, ,,	Kittisford, Som.	13/11/24	1.056	0.60	0.22	1.3	26/1/25	1.037
	SWEET VARIETIES—								
10	Sweet Alford	Long Ashton, Som.	22/10/24	1.040	0.26	0.16	5.0	5/11/24	1.024
11	Woodbine	Kittisford, Som.	17/11/24	1.048	0.32	0.22	5.2	15/12/24	1.025
12	Bedan	Normandy, France	9/1/25	1.052	0.16	0.15	3.2	16/2/25	1.026
13	Bouteille	,, ,,	9/1/25	1.044	0.16	0.15	4.2	16/2/25	1.026
	BITTER SWEET VARIETIES—								
14	Cimetière	Normandy, France	28/10/24	1.046	0.16	0.28	8.5	19/1/25	1.022
15	Matois Blanc	,, ,,	28/10/24	1.047	0.25	0.25	3.1	19/1/25	1.023
16	Bisquet	,, ,,	28/10/24	1.044	0.28	0.26	9.2	8/12/24	1.023
17	Mansel Seedling	Byford, Her.	19/12/24	1.043	0.26	0.27	4.1	19/1/25	1.022
18	White Norman	Moorhampton, Her.	20/10/24	1.050	0.38	0.24	6.6	1/12/24	1.024
19	Devon Bittersweet	Dymock, Glos.	19/11/24	1.057	0.29	0.32	6.8	15/12/24	1.024
20	Royal Wilding	Nunnington, Her.	19/11/24	1.054	0.25	0.33	5.8	15/12/24	1.025
	CULINARY VARIETIES—								
21	Worcester Pearmain	Putley, Ledbury, Her.	27/9/24	1.066	0.68	0.19	12.2	13/10/24	1.009
22	,, ,,	Glewstone, Ross, Her.	3/10/24	1.049	0.53	0.13	10.7	13/10/24	1.010
23	,, ,,	Hownhall, Ross, Her.	25/9/24	1.067	0.68	0.16	5.7	8/12/24	1.028
24	Bramley's Seedling	Ledbury, Her.	4/12/24	1.036	0.88	0.12	9.3	15/12/24	1.019
25	,, ,,	Stockton, Worcester	4/12/24	1.037	0.82	0.15	7.6	15/12/24	1.023
26	,, ,,	Glewstone, Ross, Her.	19/12/24	1.040	0.80	0.12	7.0	29/12/24	1.025
27	,, ,,	Hownhall, Ross, Her.	4/12/24	1.041	0.93	0.15	2.1	20/12/24	1.031

	PERRIES—										
28	Mixed Pears	.. ..	Long Ashton, Som.	25/9/24	1.042	0.37	0.08	6.5	13/10/24	1.017
29	Blakeney Red	.. ..	Dymock, Glos.	22/10 24	1.041	0.46	0.22	3.0	15/12/24	1.026
30	Mixed Pears	.. ..	Dymock, Glos.	10/10/24	1.045	0.53	0.19	4.7	13/10/24	1.027
	MIXED FRUIT—									
31	Mixed Apples	.. ..	Kenn & Kingweston, Som.	7/11/24	1.046	0.44	0.22	6.5	24/11/24	1.019
32	,, ,,	.. ..	Martock, Som.	26/11/24	1.050	0.42	0.34	6.4	15/12/24	1.021
33	,, ,,	.. ..	Hereford	19/11/24	1.050	0.64	0.21	4.2	9/12/24	1.026
34	,, ,,	.. ..	Normandy, France	30/10/24	1.046	0.22	0.27	4.6	15/12/24	1.026
	CIDERS made from Juices pasteurised at 160° F. and fermented with pure Yeasts.									
*35	Mixed Apples, No. 5	..	Normandy, France	19/12/24	1.046	0.29	0.24	4.0	19/1/25	1.024
*36	,, ,, ,,	..	,, ,, ...	19/12/24	1.046	0.29	0.24	4.0	23/2/25	1.024
*37	,, ,, ,,	..	,, ,, ...	19/12/24	1.046	0.29	0.24	4.0	23/2/25	1.026
*38	Mixed Apples, No. 6	..	,, ,, ...	22/1/25	1.042	0.21	0.17	4.0	23/2/25	1.025
*39	,, ,, ,,	..	,, ,, ...	22/1/25	1.042	0.21	0.17	4.0	16/2/25	1.026
*40	Mixed Apples ,,	..	Kingweston, Som.	2/12/24	1.045	0.38	0.35	4.8	2/2/25	1.026
*41	,, ,, ,,	..	,, ,, ...	2/12/24	1.045	0.38	0.35	4.8	2/2/25	1.026
*42	,, ,, ,,	..	,, ,, ...	2/12/24	1.045	0.38	0.35	4.8	2/2/25	1.025
*43	Mixed Apples ..	..	Kittisford, Som.	9/12/24	1.046	0.30	0.20	4.0	19/1/25	1.023
*44	,, ,,	..	,, ,, ...	9/12/24	1.046	0.30	0.20	4.0	2/3/25	1.026
*45	,, ,,	..	,, ,, ...	9/12/24	1.046	0.30	0.20	4.0	2/3/25	1.026
*46	,, ,, ..	..	,, ,, ...	9/12/24	1.046	0.30	0.20	4.0	2/3/25	1.025

*35 Control (fermented naturally).
*36 Fermented with Yeast No. 6.
*37 ,, ,, ,, No. 37.
*38 Control (fermented naturally).
*39 Fermented with Yeast No. 9.
*40 ,, ,, ,, No. 6.
*41 ,, ,, ,, No. 9.
*42 ,, ,, ,, No. 37.
*43 Control (fermented naturally).
*44 Fermented with Yeast No. 6.
*45 ,, ,, ,, No. 9.
*46 ,, ,, ,, No. 37.

REPORT ON ADVISORY WORK, 1924-25.

During the year the scheme devised in 1924 for the future conduct of advisory work in the Department was in full operation.

Under this scheme all problems relating to Agriculture are dealt with in the new laboratories and offices at 22, Berkeley Square, Bristol, whilst Horticultural problems receive attention at Long Ashton Research Station and those relating to the subjects of the preservation of fruit and vegetables at the Chipping Campden Research Station.

The Advisory Officers are located as follows :—

Berkeley Square :	Chief Advisory Officer.
	Agricultural Chemist.
	Economics Officer.
	Assistant Dairy Bacteriologist.
Long Ashton :	Economic Entomologist.
	Economic Mycologist.
	Willow Officer.

The Entomologist and Mycologist are stationed at Long Ashton, as a large proportion of their work is of a horticultural character.

The post of Advisory Agricultural Chemist was filled by the appointment of Mr. A. W. Ling, N.D.A., formerly on the assistant staff of Long Ashton Research Station, on November 12th, 1924, whilst Mr. H. R. Jones, B.Sc., formerly a student in the Department of Botany of the University, was appointed to the new post of Assistant Dairy Bacteriologist on March 9th, 1925. In the Department of Agricultural Economics, Mr. R. W. Hale was appointed as Student Assistant to Mr. Weller on January 19th, 1925, under the scheme of the Ministry of Agriculture and Fisheries.

The number of enquiries dealt with during the year shows a large increase over previous years. This increase is mainly due to the development of the advisory work at Berkeley Square, though there is a slight increase in the numbers dealt with by the Long Ashton staff. This latter fact is significant on account of the transfer of many enquiries to the Berkeley Square Centre, which in previous years would have been dealt with at Long Ashton, and serves to substantiate the view expressed in last year's report that the large amount of advisory work carried out at the Centre will be maintained in future years.

The statistics of enquiries for the past five years are given in the following table, which shows also the numbers received from each of the counties comprising the Bristol Province.

	Year ending September 30th.				
	1921	1922	1923	1924	1925
Gloucester (including Bristol)	73	78	136	137	194
Hereford	22	21	62	107	88
Somerset	96	114	141	130	395
Wiltshire	10	18	66	24	117
Worcester	45	56	48	78	78
Other areas	125	201	205	195	222
Totals ..	371	478	658	671	1094

Included in the figures under " other areas " are enquiries received from Devon and Monmouth, both of which counties contribute annual grants to the Long Ashton Institute, although not forming part of the Bristol Province. The figures given have reference only to enquiries dealt with by correspondence and do not include the large numbers which are dealt with in personal interviews with farmers on their farms and at the Research Station. The enquiries relating to Agricultural Economics, Willows, and Fruit and Vegetable Preservation are not included in these statistics. Separate reports of the Advisory Officers in the two former subjects are appended, whilst the advisory work on fruit and vegetable preservation is dealt with in the report of the Campden Station.

The Advisory Officers have continued to work in very close co-operation with the County Authorities and have taken an active part in the county experiments throughout the province.

A comprehensive series of spraying trials with tar-distillate washes was carried out during the year in conjunction with the Advisory Officers of the Harper Adams Province. The trials aroused much interest among the fruit growers of the area.

An important feature of the work at Berkeley Square has been the large amount of work carried out in the Department of Dairy Bacteriology. The Clean Milk Competitions held in the counties of Gloucester, Worcester and Wilts were highly successful, and led to a keen demand for advice on milk.

Excellent progress has also been made in the newly established Department of Agricultural Economics, the main features of which will be noted in the report of the Advisory Officer in that subject.

The following sectional reports serve to show the nature of the enquiries dealt with and the main features of the advisory investigations carried out during the year.

The sections dealing with Agriculture, Agricultural Chemistry, Agricultural Economics, Economic Entomology, Economic Mycology and Willow Culture have been respectively contributed by Dr. J. A. Hanley, Mr. A. W. Ling, Mr. E. P. Weller, Mr. L. N. Staniland, Mr. R. M. Nattrass, and Mr. H. P. Hutchinson, the Advisers in those subjects.

Nature of Enquiries.

Cider.—The number of enquiries received during the year was 218. The sources of these are indicated in the following table :—

Gloucester	34
Hereford	12
Somerset	48
Wilts	2
Worcester	25
Other areas	97
	218

The advisory work in connection with cider making during the year under review has been marked by a new development. For some time past the Station, in conjunction with the Ministry of Agriculture and certain County Councils of the West of England, has had under consideration the provision of a scheme of local instruction in cider making. While it has not yet been possible to put the scheme proper into operation, a preliminary scheme was carried out for the cider making season of 1924-25. Under this scheme 13 demonstrations in cider making were given by Mr. Grove in the following counties :—Devon (3), Gloucester (3), Monmouth (2), Somerset (2), Worcester (3). The numbers in brackets indicate the number of demonstrations in each county. During the season, also, several cider factories were visited by him, and a demonstration of the use of a cider filter was given at Arlingham, Glos.

The advisory work for the year has shown certain points to be of outstanding interest at present. There has been frequent enquiry for information as to the best sorts of apples to plant in cider orchards, indicating a definite revival of interest in the planting of vintage orchards. As regards varieties, the question has often been raised as to the value of culinary and dessert apples for cider making, and the possibility of finding an outlet for low-grade apples in this direction.

A further point of frequent enquiry is the means of arresting fermentation of the juice at any desired point. While this is normally done by filtration, the cost of an efficient filter is relatively high, and many small makers are asking for a cheape form of filter, or for some efficient alternative method.

Among the larger manufacturers it is evident that considerable attention is now being given to the problem of storage of cider after fermentation, and many enquiries have been received in connection with the use of glass-lined cement storage vessels and alternative forms of storage.

The issue of the proposed regulations by the Ministry of Health on the use of preservatives in foods and drinks has brought forward many enquiries on the subject of preservatives in cider, more particularly on the action and amount of sulphur dioxide, this substance being the only preservative to be permitted in future.

Pomology.

The number and sources of the pomological enquiries dealt with are given in the accompanying table :—

Gloucester	14
Hereford	7
Somerset	25
Wilts	8
Worcester	2
Other areas	43
	99

During the year there have been few points of an unusual character arising in connection with the enquiries received through the post. The Station's exhibit at Wembley was responsible for arousing interest in methods for bringing unfruitful trees into bearing, and a number of enquiries on " ringing " and other methods of a similar purpose resulted. The question of the production of alcohol from low-grade apples has been raised, and special attention is being given to the possibilities in this direction.

The investigations on the pathology of the strawberry in progress at Long Ashton have aroused much interest among strawberry growers and brought in applications for advice from all the leading districts where this crop is grown.

The major part of the advisory work on pomology is done in connection with visits to and personal interviews with growers, either on their own farms or at the Institute. This is not recorded in the statistics given, which refer only to enquiries received through the post.

Agriculture.

The special work in connection with the Ministry's Grass Land Campaign has been continued during the summer. Most of the advisory problems requiring visits to farms have resulted from enquiries on the improvement of grass land. The competition on laying down land to grass in Herefordshire has been judged by Dr. Hanley, in conjunction with a local farmer.

Arrangements have been made to work in conjunction with the Bath and West Agricultural Society on the following problems :—

(*a*) Bracken Eradication.
(*b*) Manuring of Acid Pastures.
(*c*) Production of Ground Limestone and Burnt Lime on the Farm.

This work has been carried out hitherto at Long Ashton where the Agricultural Chemist was previously stationed.

Agricultural Chemistry.

During the year 239 requests for advice were received. The sources of these are shown in the following table :—

Gloucester	52
Hereford	36
Somerset	77
Wilts	61
Worcester	3
Other areas	10
	239

The materials examined include feeding stuffs, manures, limes, etc. and soils.

The following samples have been received :—

Soils	203
Manures	31
Feeding Stuffs	25
Lime	18
Honey	1
Rat Poison	1

The Advisory Chemist has paid 63 advisory visits as the result of requests from farmers for advice concerning :—

Manuring.
Liming.
Crop failures.
Feeding and Foodstuffs.
Poultry.
Rat Destruction.

Many of these visits have been made in collaboration with a member of the Agricultural Staff of the county concerned.

An active part has been taken in the grassland experimental manurial work in the Province and in addition to the above advisory soil samples, 48 soils coming from these grassland plots have been examined.

Several phosphatic manurial trials on grass lands have been

established in conjunction with the County Agricultural Staffs in the Bristol Province.

In connection with the liming scheme of the Ministry, one new centre has been laid down in Gloucestershire and one in Worcestershire. Periodical visits have been made to the existing centres in Herefordshire and Gloucestershire.

An investigation has been started to ascertain the economic value of a powdery lime deposit containing approximately 90 per cent. carbonate of lime discovered near Hereford. This deposit seems to be fairly extensive and if the material can be cheaply quarried it should be of considerable value to Herefordshire farming, as there are large areas of " sour " land in the vicinity of the deposit.

At the request of the Poultry Instructor for Somerset an enquiry was made into the cause of the death of many head of poultry in the Shipham district of Somerset. The trouble appeared to be due to the feeding of natural grit from a local lime quarry which contained appreciable amounts of lead sulphide.

A small soil investigation has been made of typical soils in North Wiltshire. In collaboration with a Seed Testing Officer of the Ministry, a study is being made of the feeding value of " deceptive " samples of cereals.

Educational exhibits were prepared for the Three Counties Show at Hereford, the Somerset County Show at Weston-super-Mare and the Wilts County Show at Warminster.

Dairy Bacteriology.

The laboratory for the examination of milk samples was equipped and ready for use in January, 1925. It was originally established in order to satisfy the demand for the examination of Clean Milk Competition samples from counties in the Bristol Province. This work has developed very considerably since then and additional equipment became necessary and was obtained in August, 1925. In addition to Clean Milk Competition samples, a number of milk samples have been examined in response to enquiries from farmers who, during the winter, were obtaining milk of unsatisfactory quality.

Milk samples have been examined and advice given to farmers who were desirous of obtaining a licence for the production of graded milk. Visits to farms have been paid in this connection.

The following lists provide details of milk samples examined during the year :—

CLEAN MILK COMPETITION SAMPLES.

Gloucester	65
Worcester	50
Wilts	407

ADVISORY SAMPLES.

Sources of Enquiries.

Gloucester	9
Somerset	155
Wilts	23

Nature of Enquiries.

Bacteriological Examination	47
Chemical Analysis only	165

Samples are now received regularly from some producers of "graded milk."

Horticultural Chemistry.

During the year 62 requests for advice were received. The sources and nature of the enquiries are given below.

Sources of Enquiries.

Gloucester	17
Hereford	5
Somerset	15
Wilts	3
Worcester	8
Other areas	14
	62

Nature of Enquiries.

(*a*) *Soil Manurial Problems.*

Orchard and Fruit Plantation soils	18
Market Garden and Nursery soils	7
Garden soils	4
	29

(*b*) *Miscellaneous Soil Problems.*

Soil Conditions causing Chlorosis of Fruit Trees	5
,, ,, in cases of Leaf Scorch of Fruit Trees	2
,, ,, ,, failure of Fruit Crops	10
,, ,, ,, ,, Market Garden and Garden Crops	4
Suitability of Soils for Fruit Growing	3
,, ,, ,, Market Tomato Growing	3
	27

(c) *Miscellaneous Enquiries.*

Manurial Value of Samples of Wood Ashes	2
Agricultural Value of Samples of Lime Materials ..	4
Value of Stable Manure containing Sawdust	1
Manurial Value of Compound Manures	2
Manurial Value of Samples of Flue Dust	1
„ „ „ Banana Refuse	1
Causes of Leaf Scorch on Apple Trees	1
Use of Galvanised Wire Netting over Strawberries ..	1
Action of Manganese Compounds in Fertilisers	1
	14
Number of visits paid in the course of Advisory Work ..	11

Observations on Enquiries.

From the foregoing lists it will be seen that the whole of the enquiries related to problems in connection with the nutrition of fruit trees and other horticultural plants.

The problems did not present any features of a novel character which have not been hitherto encountered in the course of advisory work.

The most interesting of the cases were those concerning crop failures and chlorosis of trees. In all cases of the latter the soils on which the chlorotic trees were growing contained high percentages of carbonates.

Special Investigations in Progress.

(1) *Field Experiment on "The Winter Killing of Market Garden Crops."*—This experiment was carried out at the request of the Bristol Market Gardeners' Association in an old-established market garden in Bristol, where winter-killing had occurred for several years. It was shown that the killing did not take place when ample supplies of potash manures were given to the plants. The results of the investigation will be published shortly in "The Journal of Pomology and Horticultural Science."

(2) *Field Experiments on "The Manuring of Fruit Trees, Bush Fruits, etc."* :—

(*a*) Effect of Dung and Potash on Leaf Scorch (Expts. continued)—in Worcester, Hereford and Somerset.

(*b*) The Effect of Autumn and Spring Dressings of Fertilisers on Apple Trees (Expts. continued)—in Worcester.

(*c*) The Effects of Artificial Manures on Bush Fruits—in Herefordshire.

(*d*) The Effect of Nitrogenous Fertilisers on Apple Trees under conditions of Poor Cultivation—in Herefordshire.

(3) *Various Experiments with a view to the Control of Lime-induced Chlorosis in Apple and Plum Trees*—in Worcestershire and Somerset.

(4) *Survey of Fruit Soils on the Old Red Sandstone Formation in the West Midlands.*—Laboratory work on the soil samples was continued.

Economic Entomology.

The number of letters of enquiry dealt with during the year was 171, distributed among the counties as follows :—

Gloucester	35
Hereford	18
Somerset	31
Wiltshire	12
Worcester	24
Other Counties	51
	171
Number of Farms visited	87

This number shows an increase of 58 enquiries on last year. In addition to the above mentioned enquiries, others were received which were referred to the County Authorities. In all cases enquiries from other counties were referred to the Advisory Officers concerned, unless the information was required in connection with special work being carried out at Long Ashton. Much information has been given to growers visiting the Research Station and also in the field, on the growers' own plantations and on farms.

The following were among the most serious pests during the year :—

Capsid Bugs (*Plesiocoris rugicollis* and *Lygus pabulinus*).

(*a*) *Plesiocoris rugicollis* has been widespread throughout the province, and a fair percentage of the enquiries received during the year have referred to it. The Evesham, Pershore and Cheltenham districts have suffered most severely, whilst bad attacks also occurred in Herefordshire. Damage has been noted in Somerset, but not nearly so serious in that county as in the others.

In the case of apples, Newton Wonder, Cox's Orange Pippin, Worcester Pearmain and Charles Ross, seem to have suffered most, judging from the cases examined. In a number of cases, practically the whole crop has been rendered almost unsaleable. Serious damage has also been done to the shoots by the winged adults during July, shoot growth in some cases having been very severely retarded and numbers of side-shoots pushed out in consequence.

During July the winged adults migrated to Black currants causing serious damage to the leaves and producing a " temporary reversion." Cases have, however, been observed (notably in the Evesham District and in Hereford) where the damage has commenced on Black Currants in late April and May, which would seem to indicate that the eggs of the Capsid were laid in the shoots of the Black Currant.

(*b*) *Lygus pabulinus*.—In the Cheltenham district this has been found, in company with *Plesiocoris rugicollis*, on Black Currants. *Lygus pabulinus* migrated, as far as could be seen, from potatoes to gooseberries and then to Black Currants. *Lygus pabulinus* and *Plesiocoris rugicollis* were both observed feeding on strawberries in July and, together, practically destroyed the crop.

It is realised that the question of Capsid bugs is of the greatest importance. Arrangements have been made during this year for much work on these pests to be carried out during the coming season. Trials made during the year are dealt with in the Annual Report of the Long Ashton Research Station, 1925.

Apple-Blossom Weevil (*Anthonomus pomorum*). This pest has been even worse this year than last, particularly in Somerset and parts of Gloucestershire.

Apple Sawfly (*Hoplocampa testudinea*). Attacks were fairly severe this year. The worst cases have been noted in Gloucester.

Codlin Moth (*Cydia pomonella*). There has been a very marked increase in the number of enquiries in connection with this pest.

Willow Aphis (*Cavariella capreae*). Damage was more serious than usual in Somerset. This has led to work being carried out on it.

Willow Beetles (*Galerucella spp.* and *Phyllodecta spp.*). Cases were very numerous in Somerset.

Strawberry Troubles. Apart from " Red Plant " and " Cauliflower," the chief trouble has been damage by the larvae and adults of the weevil (Otiorhynchus sulcatus). Damage by the larvae of the common Swift Moth (Hepidlus lupulina) has been more general than last year. Reference is made later to Strawberry work.

Pear Midge (*Contarinia pyrivora*). This pest appears to be on the increase. It is hoped to commence some work on it during the coming season. The Evesham district and parts of Gloucester are suffering most from its ravages.

" *Leather-jackets* " (*Tipula spp.*). More enquiries concerning " leather-jackets " have been received this year than during last

year, particularly from Somerset. The enquiries have chiefly been in connection with mangolds, sugar beet and barley.

Cabbage Root Fly (*Chortophila brassicae*). This pest has been the source of much trouble in the Evesham district.

Gooseberry Sawfly (*Nematus ribesii*). This year, Gooseberry Sawfly continued to be serious, where no spraying was carried out.

Red Spider. This pest has given much trouble generally, particularly on Plums and Gooseberries.

Mealy Plum Aphis (*Hyalopterus pruni*). Numbers were greatly increased as compared with last year. Parasites, however, considerably reduced them.

Many enquiries were received in connection with tar-distillate washes for winter use, miscible oil sprays for summer use against Capsid bugs and other insects, and "Calcium Cyanide" for glasshouse fumigation.

The remainder of the enquiries dealt principally with the following:—

(*a*) Pests.

Host Plant.	Pest.
Apple	Apple and Pear Leaf Blister Moth (*Ornix petiolella*)
,, ...	The Bark-feeding Tortrix Moth (*Semasia woeberiana*)
,, ...	Woolly Aphis (*Eriosoma lanigera*) and its parasite (*Aphelinus mali*)
,, ...	Goat Moth (*Cossus cossus*)
,, ...	Ants
,, ...	Lackey Moth (*Malacosoma neustria*)
,, ...	March Moth (*Anisopteryx aescularia*)
,, ...	Vapourer Moth (*Orygia antiqua*)
,, ...	Winter Moth (*Chaeimatobia brumata*)
,, ...	Yellow-tail Moth (*Porthesia similis*)
,, ...	Eyed Hawk-moth (*Smerinthus ocellatus*)
,, ...	Permanent Apple Aphis (*Aphis pomi*)
,, ...	Rosy Apple Aphis (*Anuraphis roseus*)
,, ...	Apple Leaf Blister Mite
,, ...	Apple Sucker (*Psylla mali*)
Apple, Plum and Black Currant	Clay-coloured Weevil (*Otiorhynchus picipes*)
Plum	Plum Sawfly (*Hoplocampa fulvicornis*)
,, ...	Leaf-curling Plum Aphis (*Anuraphis prunina*)
Black Currant ..	"Reversion" and Big-Bud
,, ,, ..	Aphis (*Capitophorus ribis*)
Raspberry	Raspberry Shoot Moth (*Incurvaria rubiella*)
Pear..	Pear Slug-worm (*Eriocampa limacina*)
Celery and Parsnip	Celery Fly (*Acidia heraclei*)
Onion	Onion Fly (*Phorbia cepevorum*)
,, ...	Cabbage Moth (*Barathra brassicae*)
Field Bean (seed fumigation) ..	Pea and Bean Weevil (*Bruchus pisi*)
Runner Bean ..	Bean Aphis (*Aphis rumicis*)
Carrot	Aphis (*Cavariella capreae*)
Chrysanthemum ..	Eelworm (*Aphelenchus sp.*)
Beet and Mangold..	Mangold Fly (*Pegomyia betae*)
Wheat	Ear Cockles (*Tylenchus tritici*)

(*b*) Miscellaneous.

Feeding habits of larvae of Cinnibar Moth (*Hipocrita jacobaeae*).

Wheat Weevils in stored cereals (Calandra).

General damage in gardens and allotments by cockchafer larvae, slugs, snails and millipedes (*Julus pulchellus*).

The possible relations between Tomato eelworm and the Strawberry eelworm.

Fly puparia in milk.

The large red Ichneumon (*Ophion luteus*).

Clothes moths, fleas, *Drosophila sp.* infesting a hospital. Parasitized aphids, hover-fly larvae, Oribatid mites on Plum trees and the destruction of fly larvae in manure.

Grease-banding, combination insecticides, Casein spreaders, liquid soap and spray programmes in general.

Field Investigations and Trials carried out in the Counties.

Capsid Bug (*Plesiocoris rugicollis*). During the year, trials have been carried out in the Cheltenham district against *Plesiocoris rugicollis* on Apples. The following treatments were given :—

1. Tar-distillate washes against the eggs in the winter.
2. Late lime-washing against eggs just before the hatching period.
3. Nicotine.
4. Miscible oil sprays.

The trials have indicated that the most promising line for the control of Capsid bugs lies in the use of certain tar-distillate washes in the winter, followed by miscible oil sprays in the spring.

Tar-distillate Washes for Winter Use. Trials of five brands of these washes have been carried out in the province in collaboration with the Research Entomologist, the Research and Advisory Mycologists and County Agricultural Staffs. The planning of the individual trials and the application of the sprays were carried out by the Advisory Mycologist and the writer, both of whom examined the trials later in the season. A full account of these results appears elsewhere in this Annual Report.

The Loganberry Beetle (*Byturus tomentosus*). A trial was carried out in Somerset against this pest, similar to that referred to in the

report on the work for 1924. The trial, however, again failed to yield the data required. It is hoped to repeat it at Long Ashton next season. It is anticipated that weather conditions favourable to Lead Arsenate spraying will be obtained more readily at this centre than at centres hitherto selected for such trials.

Plum Sawfly (*Hoplocampa fulvicornis*). A trial was carried out against Plum Sawfly, using Lead Arsenate paste, with a casein spreader, and Lead Arsenate powder with a casein spreader. Unfortunately, the pest was not present in sufficient number to yield any reliable data. The variety of plum on the plot was Heron, and the trees had been very badly attacked in the previous year.

Apple Blossom Weevil (*Anthonomus pomorum*). A trial of a miscible oil spray was carried out in Hereford, the spray being applied on a still, warm day in March at a strength of 4%. It was hoped that under these weather conditions the active weevils might be hit. No data were obtained, as again the pest was not present in sufficient number. Since Apple Blossom Weevil is definitely on the increase, a great effort will be made to repeat this trial under suitable conditions next season.

Trials of "Calcium Cyanide" as a fumigant for greenhouses. Trials of this substance as a fumigant for greenhouses have been carried out at Long Ashton and at several centres in Somerset. The advantages of this material over the Sulphuric Acid—Potassium (or Sodium) Cyanide method appeared to be that a low concentration of hydrocyanic acid gas was given off by contact with the moisture in the house, over a long period, instead of a high concentration over a short period. The conditions for fumigation were the same as for the ordinary acid method. The first trials were carried out at a strength of $\frac{1}{4}$oz. per 1,000 cubic feet, the material being dusted down the paths of the house. Later, $\frac{1}{2}$oz. per 1,000 cubic feet, was tried. It was found necessary, however, to increase the dose to $\frac{2}{3}$oz. per 1,000 cubic feet in order to get a good kill with certainty. It was found that the same number of fumigations as in the case of the acid method were required. There is far less danger to the operator in carrying out the fumigation with Ca. Cyanide than from the use of a cyanide and acid.

So far, fuchsias and tomatoes have been treated, and in no case was any damage to the plants detected.

Field and Laboratory Work at Long Ashton.

Willow Aphis (*Cavariella capreae*). As a preliminary to field trials next season, observations on the behaviour of the aphis have been made in the Willow plantation at Long Ashton. Spraying trials with oil sprays have also been carried out both in the plantation

and on pot plants, and methods of spraying willows were tried. The work has been done in collaboration with the Willow Research Officer and will be continued next year.

Strawberry Aphis (*Capitophorus fragariae*). As the result of infection experiments, evidence has recently come to hand that Strawberry Aphis may be of greater importance than has hitherto been supposed. In addition to infection experiments, observations have been made in the field at Long Ashton and in the counties. The work is being carried out in collaboration with the Research Mycologist.

Strawberry Eelworm (*Aphelenchus fragariae*). Work on hot water treatment of runners has been continued.

Oil Sprays. Since such good results have been obtained with the commercial brand of miscible oil used in trials against Capsid bugs, an investigation of a somewhat wider character has been undertaken. Nicotine being too costly for general use against fruit pests, it is thought that a cheap and equally efficient substitute may be found in the form of an oil spray. A series of oils of a promising nature is being tested against Capsid bugs and as a general contact insecticide. An oil spray which is cheap and efficient, and which the grower can easily mix for himself, is aimed at. A spray likely to fulfil these conditions has been obtained.

Agricultural and Horticultural Shows.

In the course of the year exhibits have been staged and attendance made at the Shows listed below :—

Somerset Agricultural Show, Weston-super-Mare.
Wiltshire Agricultural Show, Warminster.
Three Counties Agricultural Show, Hereford.
Cheltenham Floral Fête.
Imperial Fruit Show, Birmingham.

During the above mentioned Shows much advice was given to a considerable number of growers and farmers.

Economic Mycology.

The total number of enquiries dealt with by post during the year was 116.

Sources of Enquiries.

Gloucester	33
Hereford	10
Somerset	44
Wiltshire	7
Worcestershire	16
Other Counties	6
	116

Visits.

Visits paid to farmers and growers, 125.

General Observations on Enquiries.

The number of enquiries shows a decrease of 26 on last year—6 enquiries were received from counties outside the Province as against 28 last year. These six were referred back to the respective provincial advisors. Eight enquiries only were received from farmers, the remainder being from fruit growers, market gardeners, nurserymen and private gardeners. The fall in the number of enquiries is largely due to the absence of any epidemic outbreak of disease such as occurred last year. Many of the enquiries constituted local problems and necessitated a certain amount of laboratory research.

No epidemic outbreak occurred this year of the "Potato Late Blight," the "Chocolate Spot of Beans," or the "Black Currant Leaf Spot" (*Pseudopeziza ribis*), all three of which caused serious loss last year. Observations on the more important diseases are as follows:—

(1) *Black Scab* (*Venturia inæqualis* and *pirina*). The Black Scab diseases of apples and pears (*Venturia inæqualis* and *pirina*) were prevalent, but not so serious as last year. In connection with the above, ripe perithecia of *Venturia pirina*, the pear Scab, were obtained in scabbed leaves that had been exposed in a wire cage over winter. These were also found later on leaves that had wintered naturally in grass orchards.

(2) *Canker* (*Nectria galligena*). Considerable damage has been done by the Canker fungus in girdling young shoots and killing spurs of both apple and pear trees. This form of attack has been very prevalent and widespread.

(3) *Wither Tip of Apples.* (*Monilia cinerea*). An interesting form of Wither Tip of apples was observed in Somerset. In a large mixed orchard many of the trees showed foliage on the young wood to be withered. Examination showed in each case a canker caused by a bud infection at the base of the withered portion. "*Monilia cinerea*" (was isolated from these cankers).

(4) *Bacterial Shot Hole of Plums and Cherries.* This disease, reported as new to the province last year (Station report of the Advisory Mycologist, 1924) now appears to have become general; the leaves, young wood and fruit are attacked.

(5) *Ring Spot of Lettuce* (*Marsonina panattoniana*). This disease continues to cause serious loss in market gardens. Dipping the seedlings in Bordeaux mixture is being tried as a means of control.

(6) *Celery leaf Spot* (*Septoria apii*). Since the war this disease has become serious in the Bristol area. Trials have been carried out by growers, on a commercial scale, of sterilising the seed, spraying the young plants before planting out and again spraying the crop in the field, with satisfactory results.

(7) "*Die-Back*" *Diseases.* The "Die-Back" of apples, plums and other stone fruit trees continues to cause much anxiety among growers, especially nurserymen. Several plantations were visited where trees of all ages had died during the summer. Such cases were generally found to occur in low-lying or unsuitable situations. While *Diaporthe perniciosa* was almost invariably present both in the "Die-Back" from the top of the tree and the infection at ground level, in most cases the root systems of such trees were diseased and the tissues invaded by numerous fungi. It is suggested that this serious outbreak of "Die-Back" is the aftermath of the wet season of 1924. Some contributory cause could in most cases be found, such as root and collar wounds by implements, too deep planting, a hard clay "pan" near the surface, a weak, poorly developed tree (probably unsuitable stock) or a thoroughly unsuitable low-lying situation. Such trees may be attacked months before any visible signs appear. It is the sudden wilting of the whole tree or trees in the orchard that gives the grower so much concern, as a virulent parasite is suspected.

Where soil conditions cannot be ameliorated, great importance is attached to the choice of varieties. Bramley's Seedling and Allington Pippin have been observed to thrive in a damp situation, where the varieties Devonshire Quarrenden and Worcester Pearmain have died. It is only in the advent of an exceptionally wet season, leading to water-logging of low-lying or badly drained land that such susceptible varieties are likely to become attacked by feeble parasites or soil saprophytes.

Several trees in the province have fallen a prey to the two destructive root parasites *Armillaria mellea* and *Rosellinia necatrix.* It is suspected that the latter is more common than is generally supposed.

(8) *Raspberry Diseases.* During the last season a number of enquiries have been received from all parts of the province relating to Raspberry diseases. The symptoms observed are as follows :—

The buds fail to break in the Spring, the canes may produce flowers, but fail to set fruit, or " Die-back " from the tip may be evident. Failure of the buds to break may lead to the development of spindly adventitious shoots from auxiliary buds. Such shoots remain weak and do not make satisfactory growth.

Examination of diseased canes showed fructifications of fungi recorded as having the raspberry as host. Little work appears to have been done on their parasitism and accordingly a rough survey of the fungi found on the raspberry and the disease symptoms was made. The subject was introduced for discussion at the conference of Advisory Officers at Oxford, in June, 1924, in order to obtain more information. Little information was, however, forthcoming.

Though fructifications of *Hendersonia rubi and Coniothryium Fuckellii* were found on diseased canes and were isolated from internal tissue, they are not regarded as being primarily responsible for the observed symptoms.

Didymella applanta (thought to be identical with the Spur Blight, *Mycosphaerella rubina* of America) occurred abundantly from small areas round the buds to large areas covering the whole of the lower part of the canes. In most cases the effect of this fungus seems to be merely superficial.

Even when the fructifications of the three aforementioned fungi were present, isolations from the inner tissue of canes yielded with great frequency *Diaporthe perniciosa.* On examination the crowns of such plants are found to be more or less invaded by fungi, causing in advanced stages a definite " Crown Rot." The plant appears to be incapable of forming the normal plug at the base of the previous season's cane—the fungi, invading which, grow down into the crown. The sucker, still free from disease, is attached to the healthy portion of the crown. It is thought that this later becomes invaded and so brings about the failure of the buds to break in the spring.

In a more advanced case of " Crown Rot," obtained from Worcestershire on May 20th, 1925, immature red perithecia were observed on the crown and main root. These perithecia contained asci each containing eight two-celled ascospores, measuring 11.2 u—14.7 u x 5.6 u—7 u. On approaching maturity the perithecia turned almost black, and on being kept in a moist chamber they extruded white tendrils of spores from the apical ostioles.

Poured agar plates of these ascospores produced violet coloured growths bearing conidia of the Fusarium type. Typical conidia

were 3—4 septate, curved with rounded extremities and measured 45 u—59 u x 6 u—8 u.

Both the perithecial and the conidial stages of the fungus agreed with Osterwalder's original description of *Nectria Rubi*. (1) This identification was confirmed by Dr. G. H. Pethybridge who had previously seen the fungus in Ireland, from which country it was recorded in 1916. (2)

Violet mycelium bearing the Fusarium type of conidia was also isolated from the inner tissue of diseased roots.

Culture work was done, and the life history of the fungus has been completed in artificial culture. Mature perithecia produced on artificial media yielded ascospores which germinated readily and produced a violet coloured mycelium bearing Fusarium conidia.

Work is being done to determine to what extent *Nectria Rubi* is a parasite. The finding of *Diaporthe perniciosa* in association with it is significant, and it may be that the two play a joint part.

Nectria Rubi appears to be fairly widely distributed. It has been found by the writer in the plantations at the Long Ashton Research Station and has also been recorded from Scotland (3); as well as from Ireland and Switzerland.

Several other fungi have been isolated from diseased crowns and roots, but are thought to be mainly saprophytic.

Mention must also be made of the general attack of the Raspberry anthracnose (*Gleosporium venetum*) especially on Baumforth's Seedling."

The widespread outbreak of raspberry diseases is possibly due in part to the excessive wet of 1924, and in part to lack of vitality brought about by old age, mosaic, and other factors.

The following list indicates the subjects of enquiry and the more interesting diseases not recorded in last year's report.

Host Plant.	Nature of Disease.	Casual Organism.
Apple	Wither Tip	*Monilia cinerea*
,, ...	Fruit Rot	*Nectria galligena*
,, ...	White Root Rot	*Rosellinia necatrix*
Pear	Fruit Rot	*Phytopthora sp.*
Plum	Scab	*Fusciladium carpophilum*
Raspberry ..	,, ...	*Nectria rubi*
,, ..	,, ...	*Didymella applanata*
,, ..	,, ...	*Hendersonia rubi*
,, ..	,, ...	*Coniothryium Fuckellii*
,, ..	Anthracnose	*Gleosporium venetum*
Gooseberry ..	Cluster Cups	*Puccinia pringsheimiana*
Asparagus ..	Root Rot	*Rhizoctonia crocorum*
,, ..	,, ,, ...	*Fusarium sp.*
Potato	" Black Dart "	*Colletotrichum tabaficum*
Mangel	Seedling Disease	*Phoma betae*

(1) Ber. d. Deut. Bot. Ges. XXIX., 1911, p. 611.
(2) F. W. Moore, Royal Dublin Society. Report on the Council for year 1916, p. 62.
(3) N. L. Alcock. Trans. & Proc. Bot. Soc. Edinburgh. 29, 1925, p. 197.

Special Investigations carried out in 1924-25.

(1) *Tar-distillate Winter Washes.* Spraying trials with Tar-distillate fluids were carried out in five orchards in the province conjointly with the Research Mycologist and the Entomological Staff. Unfortunately little information as to the effect of these washes on Brown Rot and Wither Tip was obtained, beyond the fact that the 8% washes appeared to be capable of killing the pustules of *Monilia fructigena* on mummied plum where they were actually hit by the wash. No Wither Tip was observed on the controls.

A full account of these trials will be found in the Annual Report of the Station.

(2) *American Gooseberry Mildew.* Spraying trials for the control of the American Gooseberry Mildew were carried out on three plantations in the province.

(3) *Seed Pickling Investigation.* An investigation on the effect of "pickling" on the germination of seed wheat was carried out at the request of the Ministry. Valuable assistance was given by the County Organisers for Gloucestershire and Wiltshire, who spared no pains to put the Adviser into touch with suitable farmers.

(4) *The Chocolate Spot Disease of Field Beans.* Field and pot experiments were carried out in collaboration with the Agricultural Instructor for Gloucester, following a resolution passed at the Provincial Advisory meeting.

(5) *White Rot Disease of Onions.* A trial of varieties of onion immune to the White Rot Disease *Sclerotium cepivorum* was carried out in collaboration with the Adviser in Agricultural Botany, Manchester University.

In addition to the above, preliminary experiments were carried out on growers' premises on :—

(*a*) Spraying for Apple Scab with Excess Lime Bordeaux Mixture.

(*b*) Spraying with Ammonium Polysulphide and Soft Soap to control the leaf Mould of Tomatoes under glass.

Satisfactory results were obtained and it is hoped to be able to repeat them on a wider scale during the coming season.

Special Investigations to be continued.

(1) *Raspberry Diseases.* The work begun on raspberry diseases will be continued in collaboration with the Research Mycologist. Special attention will be paid to testing the parasitism of *Nectria rubi* and *Diaporthe perniciosa* in connection with "Crown Rot" and "Die-Back."

(2) *Asparagus Disease.* At the request of the asparagus growers in the Evesham district, the work on the control of the Rhizoctonia disease of asparagus carried out by the Station staff during 1915-1916-1918 is being continued.

(3) *Collar Rots of Fruit Trees.* Work is being done on the parasitism and methods of control of the two fungi *Rosellinia necatrix* and *Armillaria mellea.*

(4) *Spraying Trials.* Routine spraying trials against American Gooseberry Mildew and Apple and Pear Scab, and tar-distillate spraying to control Brown Rot and Wither Tip, will be repeated during the coming season on growers' plantations, if suitable ones are available.

Laboratory Work.

Many of the problems dealt with necessitated an amount of isolation and pure culture work. The collection of type cultures has been added to and the following pure cultures have been distributed to other workers.

Nectria rubi
Rosellinia necatrix
Marsonina panattoniana
Diaporthe perniciosa (Special strain)
Thielavia basicola

As a preliminary to work of more economic importance, a study has been commenced of the cultural characteristics of *Rosellinia necatrix.* This fungus has been grown up to the conidial stage in pure culture.

Education Work.

During the last two years, a collection of specimens illustrating common fungus diseases of agricultural and horticultural crops has been made. This collection has been exhibited and demonstrated at the following Shows :—

Somerset Show	at Weston-super-Mare
Three Counties Show	,, Hereford
Wiltshire Show	,, Warminster
Floral Fête	,, Cheltenham

Agricultural Economics.

In considering the scope and direction of the work in Agricultural Economics in the Bristol Province, it was clear that a considerable amount of research must necessarily precede and form the basis of any serious attempt at the dissemination of advice on economic problems. At the same time, the primary function of the department necessitated that the lines of research laid down should be such as appeared to lead most directly to the accumulation of data which would be of immediate service to the agricultural industry

in the province. These considerations prompted the selection of the economics of farm management as the principal subject of investigation. This subject is of primary importance to the individual farmer who is striving to secure the best results under external conditions which are more or less beyond his control. The Advisory Officers in technological subjects are assisting him towards the attainment of this object, and economics, acting as a co-ordinating principle and directing force, will prove of great value, not only in itself, but in increasing the practical utility of the Advisory Service as a whole.

Moreover, efficient farm management is of fundamental importance in the consideration of other aspects of the industry as affecting the reward of the land owner and labourer, or the place of agriculture in the national economy, and satisfactory solution of problems presented by these considerations must presuppose the efficient utilisation by farmers of the resources under their control. In the investigation of such problems, too, the availability of a considerable proportion of the information required depends upon the goodwill of farmers, and much material valuable for such purposes will be automatically obtained in the study of the economics of farm management.

Having laid down the main lines of investigation it was necessary to determine the method of collecting material and also to develop the technique of dealing with it. Farm costing was adopted as one method of investigation in order to secure a certain measure of uniformity with work proceeding at other centres, and also because this method is, to some extent, appreciated by the more progressive section of the agricultural community. A request having been received from the Somerset branch of the National Farmers' Union for assistance in the investigation of the financial side of farming in that county, eleven farms were selected for costing. These farms together cover an area of approximately 2,812 acres, and they represent five important types of farming. With a view to encouraging the farmers concerned in the use of costing data for checking and controlling operating costs it is proposed to circulate from time to time such comparative data as is available in the accounts. Tables and explanatory notes dealing with the labour costs of operations performed during the past summer have already been circulated. It is anticipated that early information of this kind will prove increasingly valuable, not only to the farmers immediately concerned, but also to others farming under conditions fairly comparable to those under investigation.

It must, however, be recognised that the amount of costing which can be undertaken is relatively insignificant, and its results are therefore necessarily very limited in their scope and application.

With a view to developing the work of the department on a wider basis, and securing results which will be of value to a considerable number of farmers within a comparatively short space of time, a method has been devised whereby ordinary financial accounts may be used as a guide to economic farm management, while at the same time providing data which can be used for the investigation of various general problems. The number of farmers who prepare simple statements of accounts for income tax purposes is, perhaps, larger than is generally supposed, and farmers are usually willing to submit these statements for investigation. As soon as a sufficient number have been dealt with the results will be made available for the farmers concerned. With a view to establishing this work on a permanent basis, steps have been taken in conjunction with the Agricultural Officer for Wiltshire to form an agricultural accounting society in that county. A scheme drawn up by a small committee of farmers acting in conjunction with the Agricultural Officer and the Advisory Economist was laid before the County Executive of the National Farmers' Union, which passed (*nem. con.*) a resolution supporting the scheme and recommending it to members. The Agricultural Officer and Advisory Economist are now attending branch meetings of the National Farmers' Union, in order to explain the scheme. The proposal has met with general approval and a considerable measure of active support appears to be forthcoming. It would seem certain that when the utility of simple accounts can be thus demonstrated, the practice of book-keeping on sound lines will receive a considerable stimulus and the adoption of some form of costing by at least some members of the Society may quite well prove to be a later development.

With regard to other aspects of the work in agricultural economics a few requests for advice and assistance on questions relating to costing, book-keeping and economic problems have been received and dealt with. Local agricultural shows have been attended and notices and diagrams exhibited.

In addition to addressing a large number of meetings in connection with the schemes outlined above, the Advisory Economist has delivered lectures and read papers as particularised below.

"Agricultural Costing—An Aid to Farm Management."—The Surveyors' Institution, London.

"The Economic Aspect of Wintering Cattle for the Production of Farmyard Manure."—The Agricultural Education Association, London.

"Farm Management for Profit."—Swindon Agricultural Discussion Society.

"Farm Management for Profit."—Young Farmers' Class, Wotton-under-Edge. (Two lectures).

" Agricultural Costing."—The Land Agent's Society, Gloucester.

" Rates, Taxes and Tithes on Agricultural Land."—East Harptree Branch of the National Farmers' Union.

" Rates, Taxes and Tithes on Agricultural Land."—Wincanton Branch of the National Farmers' Union.

" Rates, Taxes and Tithes on Agricultural Land."—Bridgwater Branch of the National Farmers' Union.

The following articles written by the Advisory Economist have been published during the year :—

" Agricultural Costing—An Aid to Farm Management."—Transactions of the Surveyors' Institution, Vol. LVII. Part 1.

" The Value of Costing in Estimating and Controlling Expenditure."—Journal of the Land Agents' Society. Vol. XXIII. No. 2.

" Farm Income Tax Assessments."—Journal of the Land Agents' Society, Vol. XXIV. No. 5.

" The Economic Aspect of Wintering Cattle for the Production of Farmyard Manure."—Agricultural Progress, Vol. II. 1925.

" The Cost of Wintering Cattle for the Production of Farmyard Manure."—The Journal of the Ministry of Agriculture. Vol. XXXI. No. 12.

" Farm Problems."—The Western Morning News and Mercury Agricultural Supplement, 1925.

Willow Culture and the Utilization of Willows.

Condition of Crops and State of Trade.

The area of land in the country under basket willows appears to be stationary. Established growers have maintained their acreages, and have replaced grubbed beds by new planting. Small beds have been laid down for trial purposes by new growers in new districts in Northumberland, Berkshire and Pembrokeshire.

The dry weather in June of 1925 checked the growth of the willow crops in most parts of the country, and although favourable growth periods occurred later in the summer, the yields of rods from the current year's crops will be below those of 1924. The consequence will be that the Basket-making industry will find a shortage in English grown rods of the large sizes.

The willow growers are benefiting by a steady progressive increase in the price of rods, due to the increased industrial requirements in basketry. No surplus of the 1924 crop remained on the growers' hands, and willow merchants and basket-makers, as far as the 1925 crop is concerned, are desirous of buying forward.

A new feature in the willow growing industry of the country has been the introduction of Continental buyers of certain varieties of English-grown rods. The Willow Officer was informed by a Lancashire willow grower that at least 20 tons of rods had been sold to German buyers from the Ormskirk district for export at prices between £70 and £80 per ton.

Enquiries.

The total number of enquiries answered during the year was 99, distributed as follows :—

Gloucester (including Bristol)	8
Hereford	1
Somerset	26
Wiltshire	2
Worcester	7
Other areas	55
	99

Advice was given on land and crop cultural management, selection of varieties for planting, the obtaining of cuttings, the marketing of rods, the Cricket Bat Willow culture, and on the treatment of insect and fungus attacks. Land was inspected with a view to willow planting in Worcestershire (2) ; Somerset (2) ; Berkshire (1) ; and Wiltshire (1). The figures in brackets refer to the numbers of cases dealt with in each county. Special advice was given in the cases of Sewage Farms at Didcot and Street, and information was supplied to the Rural Industries Bureau and to the Rural Industries Officer for Somerset on various problems connected with the willow-growing and basket-making industries.

Cuttings for trial purposes were supplied from the Station's Experimental Trial Plots to growers in Worcester and Somerset, and consignments of cuttings were exported to :—

The Botanic Garden, Sydney, N.S.W.
The Ministry of Agriculture, Sydney, N.S.W.
The New Zealand Government, Wellington.
Canada.

Thirty-three willow growers and basket makers visited the Trial Plots.